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Stock Status of Fraser River Sockeye

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ABSTRACT

Cass, A. J. 1989. Stock Status of Fraser sockeye. Can. Tech. Rep. Fish. Aquat. Sci. 1674: 106 p.

This report presents the first formal resource assessment of Fraser River sockeye salmon since the signing of the Canada-U.S. fishing treaty in 1985. The Ricker stock-recruitment model was used to evaluate the productivity of 22 stocks. For many stocks there was considerable uncertainty in the spawner-return relationship and thus the estimates of optimal escapement. This is related to two phenomena. First is variability in stock-recruitment data caused by variable environmental effects on survival and measurement errors in the data. Second, and most serious concern, is the potential influence of year-class interaction and its effect on cyclic variation in abundance. Except for lower Fraser River stocks, where recent declines in returns have occurred, all stocks (where data exists) have remained stable or have shown increases since 1952. However, increases have mainly occurred on the dominant cycles. If a single spawner-recruit curve is appropriate then the stocks have been overfished and the opportunity for rebuilding is tremendous. Rebuilding on off-cycle lines is recommended in concert with an experimental design to identify factors influencing productivity.

RÉSUMÉ

Cass, A. J. 1989. Stock Status of Fraser sockeye. Can. Tech. Rep. Fish. Aquat. Sci. 1674: 106 p.

Le présent rapport porte sur la première évaluation formelle des ressources en saumon nerka du fleuve Fraser depuis la signature du traité canado-américain sur la pêche en 1985. Le modèle de recrutement des stocks de Ricker a été utilisé pour évaluer la productivité de 22 stocks. Pour de nombreux stocks, on a constaté une incertitude considérable dans la relation reproducteurs-retours et, par conséquent, dans l'estimation des échappés optimales. Cette situation est liée à deux phénomènes : 1° des erreurs de mesure dans les données et la variabilité dans les données sur le recrutement des stocks causée par des effets environnementaux variables sur la survie et 2°, ce qui est une source de préoccupation plus importante, l'influence possible de l'interaction des classes d'âge et ses effets sur la variation cyclique de l'abondance. Sauf pour ce qui est des stocks du cours inférieur de fleuve Fraser, où un déclin dans le nombre de saumons de retour est survenu récemment, tous les stocks (pour lesquels on dispose de données) sont demeurés stables ou ont connu une augmentation depuis 1952. Cependant, les augmentations sont survenues principalement au cours des cycles dominants. Si une seule courbe reproducteurs-recrues est appropriée, alors les stocks ont été surexploités et la possibilité de reconstitution des stocks est formidable. Il est recommandé de reconstituer les stocks à partir des lignées hors cycle (années de faible abondance) en ayant recours à une conception expérimentale permettant d'identifier les facteurs qui influent sur la productivité.

INTRODUCTION

This report presents the first formal resource assessment of Fraser River sockeye by the Department of Fisheries and Oceans (DFO) since the signing of the Canada-U.S. fishing treaty in 1985. A draft of the report was presented to the Pacific Stock Assessment Review Committee (PSARC Working Paper S88-1) in February 1988. The assessment comes at a time when rebuilding strategies of Fraser sockeye stocks are being developed by the DFO. Rebuilding policies of Fraser sockeye are one of the most important issues concerning west coast fisheries.

Sockeye salmon production from the Fraser River support the most valuable commercial fishery in British Columbia and during 1975-86 accounted for 62% of the sockeye catch. The landed value of the Canadian commercial catch from the Fraser River during that period averaged $37 million/yr. The Canadian commercial catch averaged 4.2 million fish/yr. The combined Canada-U.S. catch averaged 5.9 million fish/yr. Fraser River sockeye are also an important Indian food fishery. The average catch in the Indian food fishery during 1975-86 was 340,000 fish/yr.

This report follows nearly 50 yrs of management and data collection by the International Pacific Salmon Fishery Commission (IPSFC). Throughout that period the data used for resource assessment remained somewhat of an enigma to the DFO. The first part of this report summarizes the methods used by the IPSFC to collect data for resource assessment. The second part of this report gives an historical perspective of the fishery and issues affecting management of Fraser River sockeye. The third part presents an assessment of the productivity for 22 river-lake systems in the Fraser River watershed based on the relationship between spawning escapement and subsequent returns for the spawning years 1948-52. The report concludes with a summary of information and research needs along with recommendations for management of the Fraser River sockeye resource.

It is important to note that the transfer of management responsibilities to DFO was a recent event and a review of the data is currently in progress. Results presented here must be viewed as preliminary pending the completion of the review.

DATA SOURCES

Intensive commercial exploitation of Fraser River sockeye began with the development of canning facilities in the 1860s (Rounsefell and Kelez, 1938). There is considerable uncertainty in the estimates of the catches and particularly the escapements during the early years of the fishery. The spawning escapements for most stocks were estimated annually by the IPSFC since 1938. The catch by stock and age class were estimated since 1952. In this report, the relationship between spawning escapement and total returns (catch plus escapement) were used to assess the productivity of 22 Fraser sockeye stocks. The trend in catch, returns and escapement of Fraser River sockeye during 1915-86 are shown in Fig. 1. Annual 1948-85 escapements, returns and returns per spawner for each stock are listed in Appendix A.

ESTIMATES OF SPAWNING ESCAPEMENT

Escapement data for Fraser River sockeye are the most extensive of any system on the Pacific coast. Each year spawning escapements are estimated in about 100 streams. An historical perspective on the methods used to enumerate spawning escapement is presented in Howard and Chapman (1948) and Schaefer (1951). The following description of procedures used to estimate escapement summarizes a recent review by Andrew and Webb (1987).

Procedures used by the IPSFC included Petersen mark-recapture experiments, live and dead counts, fence counts and aerial surveys. The choice of enumeration methods used each year for a given stock is based on several criteria (Table 1). The quality of escapement data is largely dependent on the method of enumeration. Although the level of uncertainty in the data has not been evaluated, large scale Petersen mark-recapture experiments are likely more accurate than live and dead counts.

The Petersen method (Ricker 1975) is generally used if the number of spawners are predicted to by greater than 25,000 fish. Petersen estimates are performed by tagging about 1% of the number of spawners expected along with a recovery of 10-40% of the carcasses.

Adjustments to the escapement estimate are often made to account for straying of tagged fish to other streams and to estimate the numbers of precocious, age-3 males (jacks) when small numbers are present. The number of tagged strays is estimated by the equation

(1) $$S_a = R_b / M_b \times N_b \ ;$$

where, S = stray tags from stream a
R = tagged recoveries at stream b
M = total dead recoveries at stream b
N = escapement estimate at stream b

The number of strays is then subtracted from the tags applied at stream a.

Jack abundance has often been used as a predictor of adult returns in the following year. In streams where there are a low number of jacks there are often a small number of tags applied to jacks and little or no recovery of tagged jacks. In this situation the jack population are frequently estimated by the equation

(2) $$J = M \times F \times P \ ;$$

where, J = jack escapement
M = total dead recoveries of jacks
F = availability factor determined by comparing escapements using Petersen estimates and calculations based on the male recovery ratio
P = male tag recoveries / males tagged

An availability factor (F) of 1.26 was determined in the 1970s from tagging programs on the Chilko, Birkenhead, Weaver and Adams systems. These systems have large populations of jacks.

Most streams are enumerated using live and dead counts. As fish move into the spawning areas live counts are made at periodic intervals. When carcasses start to occur they are pitched and counted. The period of peak live count plus the cumulative sum of the carcasses to that date are used

along with a calibration factor determined from tag recovery experiments to estimate escapement. The calibration factor is calculated by the equation

(3) $$F = N / L + D ;$$

where, F = calibration factor
N = Petersen estimate
L = peak live count
D = cumulative dead count

The calibration has been made on a number of systems on various occasions. Factors of 1.8 and 1.9 have been used on the Stuart system. Factors of 1.8 have been used on other systems.

The dead pitch, among other things, provides data on the sex ratio and estimates of the proportion of females that have spawned (effective females). In this analysis estimates of the spawning escapement of effective females was used as a measure of parental stock. Recruitment was calculated as the catch plus total escapement of the returning progeny summed over all age groups.

ESTIMATES OF CATCH

Fraser River sockeye are caught in mixed-stock fisheries in coastal British Columbia as maturing fish migrate to their stream of origin. The stock composition of the catch was historically estimated by the IPSFC using scale traits established during freshwater life coupled with estimates of run timing and run size. The sampling methods used for scale collections are given in Clutter and Whitesel (1956). The analytical procedures used to separate the stocks using scale traits are presented in Henry (1961).

In-season management of Fraser River sockeye fisheries is the responsibility of the Pacific Salmon Commission. Samples from commercial catches and test fisheries provide the basic data to allocate the catch to the various stocks and estimate the age composition. Samples of 120 to 240 sockeye are collected weekly from as many as 12 commercial fisheries and daily from 3 test fisheries (Woodey 1987).

Circuli counts from the freshwater growth zones on scales were the principal traits used to identify stocks. The frequency distribution of circuli counts collected from the fisheries were compared to the frequency distribution of circuli from scales collected from discrete stocks on the spawning grounds. Scales from age-3 jacks collected each year from the spawning grounds were used to identify age-4 adults of the same cohort in the following year's fishery. The pre-season forecast of stock abundance, the estimated run timing and migration patterns of the stocks were used to graphically identify the modes in the frequency distributions.

At the completion of the fishery the data are re-analyzed using scales from adults of the same age collected from the spawning grounds Woodey (1987) reports that the pre-season estimates of stock composition generally agrees with the post-season results. The final estimates of recruitment are based on the post-season analysis. To estimate the returns by brood year, the catches are summed across each age group in a cohort to estimate the total returns by brood year.

Other methods of stock identification that use newly developed technologies are currently being investigated by the Pacific Salmon Commission (Cook and Guthrie 1987) and the DFO. A comparison of stock composition estimates using maximum likelihood procedures (Fournier et al. 1984) with the

estimates derived using historical methods is currently underway. The procedure may be useful to quantify and correct for possible biases in the historical catch records.

HISTORY OF THE FISHERY AND MANAGEMENT

Prior to the devastation of salmon stocks in 1913 with the obstruction at Hell's gate, the dominant runs (1901 cycle) were reported by Ricker (1987) to be 100 million sockeye with catches in the range of 35-50 million sockeye. Ricker estimated the dominant runs to be 20 times larger than the three other cycle years. The IPSFC (1973) reported catches in 1913 of about 30 million sockeye. As a result of habitat destruction, the most notable being the effect of the Hell's Gate slide in 1913, and overfishing in the years that followed, catches declined (Ricker 1987; Thompson 1945). Catches during 1915-30 averaged 1.9 million fish/yr for all cycles. During 1930-50 catches increased to an average of 2.6 million (Killick and Clemens 1963).

All stocks upriver from Hell's Gate remained at low levels until 1926, when a relatively large escapement was reported on the Lower Adams River (Larkin and Ricker 1964). Subsequently, escapement levels were variable but continued to increase. The largest escapement to the Fraser River in recent history was 4.0 million in 1958 of which 2.5 million was for the Lower Adams. Escapement to the Lower Shuswap River increased from 9,000 - 30,000 spawners on the dominant cycle in the 1950s and 1960s to 514,000 spawners in 1982 (IPSFC 1983). Escapements to the Chilko River began to increase in the 1930s as did other stocks. However, sustained increases in upriver stocks were affected by the mortalities incurred from obstacles at Hell's Gate. Following construction of the fishways in the Fraser canyon along with a 5-year fishing closure on early and mid-season runs during 1946-50 there was a marked increase in all runs.

The dynamics of Fraser River sockeye are characterized by a 4-yr cycle in abundance in many Fraser tributaries. The persistence of the classic dominant-subdominant-off-off cycle is most notable in the Lower Adams River run but is also prominent in the Lower Shuswap, Stuart and Horsefly systems. Strong variation in year-class strengths have occurred in other river-lake systems, but not in the same cyclic pattern observed for the Adams, Stuart and Horsefly ststems.

The DFO is presently developing strategies to rebuild year classes on off cycle years. The significance of interactions among adjacent year classes that rear in the same lake, otherwise known as "cyclic dominance", is the most important issue concerning the development of rebuilding plans. Ward and Larkin (1964) hypothesize that depensatory predation in the fry to smolt stage is responsible for cyclic dominance. Walters and Staley (1987) hypothesize that cyclic dominance could be caused by depensatory fishing mortality. Extensive research by the IPSFC (IPSFC 1976) has failed to resolve the issue. Collie and Walters (1987), in a simulation study, concluded that with the existing time series of escapement and return data, neither the depensatory predation nor the depensatory fishing hypotheses can be rejected as causes of cyclic dominance in Adams River sockeye. They evaluated various management strategies for Adams River sockeye by comparing simulation results using the Ricker model and Larkin's (1971) version of the Ricker model that includes lag terms for measuring interactions among year classes. Their results indicated that a high and constant havest rate is sufficient to maintain cyclic

dominance. Although, they found evidence for both depensatory fishing and predation, depensation was not a prerequisite for the persistence of cyclic dominance in Adams River sockeye.

PRODUCTIVITY EVALUATIONS

RETURNS PER SPAWNER MODELS

Several models describing the relationship between escapement (stock) and subsequent returns (recruitment) are proposed for fish populations (see Ricker 1954; Beverton and Holt 1957; Ward and Larkin 1964; Larkin 1971; Paulik, 1973; Ware 1980; Shepherd 1982). The most common models fit to these data are the "Ricker model" (Ricker 1954) and the "Beverton-Holt model" (Beverton and Holt 1957). In the Ricker model, recruitment declines as stock size increases forming a "dome-shaped" relationship. In it's linear form the Ricker model is

$$(4) \qquad \ln(R_t/S_t) = a - bS_t + \sigma\epsilon \ ;$$

where, R_t = returns in year t,
S_t = spawning stock that produced R_t,
a = density independent parameter,
e^a = returns/spawner at low stock size,
b = density dependent parameter equal to the slope of the regression,
σ = standard deviation of the residuals,
ϵ = independent normally distributed random variable with mean 0.0 and variance 1.

Larkin (1971) proposed a Ricker model with additional terms to account for possible interactions among year classes. Larkin's model can be written as

$$(5) \qquad \mathrm{Ln}(R_t/S_t) = a - b_0S_t - b_1S_{t-1} - b_2S_{t-2} - b_3S_{t-3} + \sigma\epsilon \ ;$$

where, b_t, b_{t-1}, etc. are coefficients of interactions among year classes such as predation or competition.

The Beverton-Holt model assumes that the rate of increase in returns per spawner declines asymptotically as escapement increases. The curve defined by the Beverton-Holt model forms a hyperbola. The best estimation equation that preserves the multiplicative error assumption is

$$(6) \qquad \ln(R_t) = \ln((aS_t)/b+S_t) + \sigma\epsilon \ ;$$

where, a = parameter equal to the maximum recruitment as S goes to infinity,
b = parameter is value of S at which a/2 recruits are produced,

Theoretically, the Ricker and Beverton-Holt models characterize two diverse forms of density dependency. The weakness of the Ricker and Beverton-Holt is the failure to account for potential interactions among year classes. Larkin's form of the Ricker model, while presupposing the same form of density dependency as the original Ricker model, measures first order interactions among year classes. The extra b parameters are surrogates for the effects of predators. A weakness of the Larkin model is that the predators themselves are not represented. Only the potential effects of predators on prey are represented. Another practical limitation is the inability to compute precise estimates of optimal escapement or maximum catch. Collie and Walters (1987) describe a "brute-force" method for calculating maximum catch in Adams River sockeye.

Despite years of research by the IPSFC, there are no data to determine which recruitment model best describes the form of density dependency or depensation controlling the dynamics of Fraser River sockeye. Measurement errors in stock-recruitment data generally mask the true form of density dependency (Walters 1986).

Monte Carlo simulations were performed to compare the fit of the Ricker and Beverton-Holt models to simulated data with comparable variance and harvest rates observed in Fraser sockeye escapement and return data. Simulations of 100 data sets were performed using the Beverton-Holt relationship. For each data set, 34 stock-recruitment data pairs were simulated corresponding to the observed time series of data available for Fraser River sockeye. Each data set was simulated by assuming a random, log-normal error and with $\sigma = 0.5$ and a 70% harvest rate. Recruitment parameters were selected to correspond to observed ranges for sockeye. Each simulation was started with a stock size of $S = 1.0$. For each simulated data set, 40 data pairs were generated and then the next 34 data pairs were accumulated for use in the regression to allow the dynamics of the simulations to stabilize at the desired level. The Beverton-Holt and the Ricker model were then fit to each data set. The performance of the two models were evaluated by comparing the mean of the sum of squares of the residuals for 100 data sets.

The simulation results indicate that the level of variance inherent in Fraser River escapement and return data is not adequate to distinguish the correct form of density dependency. The difference between the sums of squares was negligible and independent of the "a" and "b" parameters used in the simulations. Although more complex models may provide better fits to particular data sets, they will not identify the form of density dependency inherent in Fraser River sockeye stocks because of the large variance in the data.

The use of the Beverton-Holt model was abandoned in favour of the Ricker model under the assumption that recruitment declines at high levels of spawning escapement. There is crude evidence for low recruitment following high escapements in some Fraser River stocks (i.e. Adams River, Chilko River, Stellako River). We also abandoned the Larkin model because of the computational short-comings. Collie and Walters (1987) have demonstrated that it is not possible to determine whether the Ricker model or the Larkin model correctly encapsulates the dynamics of Fraser River sockeye. Nevertheless, because the Ricker model does not account for possible interactions among year classes, estimates of maximum catches derived from the Ricker model are more optimistic than suggested by the Larkin model.

ESTIMATING BIASES IN STOCK-RECRUITMENT PARAMETERS

Three sources of bias identified in fitting stock-recruitment curves to data are (1) measurement errors in estimates of spawning escapement (2) correlations among residuals and subsequent levels of spawning escapement and (3) autocorrelations among residuals (Walters and Ludwig 1981; Ludwig and Walters 1981, Walters 1985). All the causes of bias lead to an overestimate of the density dependent parameter, b.

Unfortunately, little that can be done to correct for bias caused from measurement errors in the historical data. Using procedures similar to Walters and Staley (1987) we investigated the significance of bias caused from correlations among residuals and subsequent escapement.

Monte Carlo simulations were performed to estimate the bias over a range of a and b parameters. Simulated data sets were generated using the two equations

(7) $$R_t = S_{t-1}e^{a-bS_{t-1}+\sigma\epsilon} \ ;$$

(8) $$S_t = R_t * 1-h_t \ ;$$

where; h_t = harvest rate in year t.

Parameters a and b were re-estimated using standard linear techniques as described above. For a and b values typical of Pacific salmonids (a=1.0 to 3.5, b=0.05 to 1.0) 100 data sets were generated using two levels of exploitation. Simulations were performed at the optimal h and at h=10% greater than optimal rate for each parameter combination. Nine and 34 stock-recruitment data pairs were generated at each level of exploitation for a total of four possible scenarios. These sample sizes are equal to the number of data pairs available on each 4-yr cycle and for all years combined, respectively. Simulations were started with S=1.0 and σ=0.7. Simulations of 40 data pairs were generated before accumulating the data pairs used to re-estimate the recruitment parameters. At each of the four scenarios 100 data setswere generated. The average of the re-estimated a and b parameters was then used as a measure of bias. The results of each simulation are presented in Appendix B.

There were no parameter combinations for which the mean of the biased parameters were statistically different ($p>0.05$) from the true parameters in either of the 4 scenarios. As reported by Walters (1985), the bias resulted in overestimates of a and particulary b and thus underestimates of optimal escapement. Simulations performed by holding spawning escapements at the optimal level and simulating 34 data pairs resulted in relatively small biases at Ricker a values typical for Fraser River sockeye (a = 2.0 - 3.0). In this scenario the Ricker b parameter was overestimated by an average of 3-6%. At sample sizes of 9 data pairs the bias increased by an average of 17-25%. Under the scenario of overexploitation the bias in b with 34 data pairs averaged 15-390%. For simulations using 9 data pairs, the bias in b was much greater and averaged 80-560% in the a range of 2.0 - 3.0. These results suggest the bias is profoundly affected by sample size and the level of stock size compared to the equilibrium stock size. In overexploited stocks the stock-recruitment curve would create the false impression that stocks would not recover appreciably following reduced fishing pressure.

Simulations were also performed to estimate and correct the bias. For simulations using all-years data, the observed estimates of effective female escapement for the first four years in the time series were used to generate a

time series of stock-recruitment data pairs equal to the number of observed data pairs for each stock. For simulations of the cycle year runs, the first year in the time series was used to generated stock-recruitment data pairs for each of the cycle years. The observed estimates of σ, the annual estimates of h and the annual proportion of effective females were used to simulate each data set. The a and b parameters were then estimated as the mean of 1000 simulations. The observed bias was generally consistent with results presented above (Table 2). The bias was largest in the density dependent parameter b. The range of bias in b for all years of data combined was from <1% for the early Chilko, Harrison, Gates and Upper Pitt River stocks to 36% for the Late Stuart stock and 38% for the Lower Adams River stock. The largest bias was for cycle years data and ranged from <1% to over 500% for the Late Stuart.

A procedure used by Walters and Staley (1987) was used to investigate bias in recruitment curves when fit to stocks with abundance estimates below the unfished equilibrium. Recruitment curves were simulated for each of the cycles for stocks that have dominant and "off-cycle" runs. The a and b parameters and σ were estimated from the time series of all-years data using standard regression techniques. The escapement in the first year in the historical time series was used as the initial stock size and the observed time series of exploitation and the proportion of effective females was used to generate 9 fake stock-recruitment data pairs for each stock. The a and b parameters were fit to data for all years and to each of the four cycle years. Simulation were repeated 1000 times to estimate the average bias in the a and b parameters.

There were no significant differences ($p>0.05$) in the a or b parameters. However, there were extremely large positive biases in b that caused the recruitment curves to bend at fractions of the true curve in every stock (Table 3). The influence of bias is illustrated for the Chilko River and Lower Adams stocks in Fig. 2. As concluded by Walters and Staley (1987), the bias appears to depends on stock size in relation to the unfished equilibrium.

To address the third source of bias mention above, the autocorrelation of the residuals was calculated by fitting the Ricker model to stock-recruitment data for all years combined in each stock. Significant deviations particularly at a lag of 4 years would imply a cyclic pattern in abundance and suggest separate stock-recruitment relationships among cycles. For each time-lag the autocorrelation was calculated using the equation

$$(9) \qquad r_k = \sum_{t=1}^{N-k} v_t \, v_{t+k} \; / \; v_t^2 \; ;$$

where, r_k = autocorrelation at lag k years.
v_t = residual at year t.
N = no of years in time series.

(source: Box and Jenkins 1976)

There were no significant differences in the autocorrelations for any of the stocks. With the exception of the Horsefly River, there was no evidence for the existence of cycles (Table 4).

ESTIMATING OPTIMAL ESCAPEMENT

Estimates of spawning escapement were calculated for each stock for all years combined and for each cycle. By definition, the optimal spawning escapement is equal to the escapement where the slope of the recruitment curve is equal to 1. By setting the first derivative of the recruitment equation equal to 1, the optimal escapement, S^*, is calculated by the equation

$$(10) \qquad 1 = (1 - aS^*/b)\exp(1 - S^*/b + (\sigma^2/2)) \ .$$

The estimates of optimal escapement corrected for time series bias were most often higher than the uncorrected estimates (Table 5). There were no significant biases in any of the stocks ($p>0.05$) and except for the late Stuart and Lower Adams stocks, the bias was negligible for most stocks when using data for all years. The bias corrected estimate was 57% higher for the late Stuart stock and 52% for the Lower Adams stock. The bias in the cycle year estimates were also negligible for most stocks but there were also some extremely large biases. For example, the Raft, Late Stuart and Bowron stocks had biases in excess of 100%. The bias for the 1985 cycle of the late Stuart stock was 530%.

STOCK STATUS

In the following section the trend in returns and escapements for each stock are discussed in relation to the preceeding stock-recruitment analysis. The mean historical escapements and catches for each stock (1948-85) are compared to the optimal escapements and corresponding maximum catches in Table 6. For all stocks the estimated optimal escapements were larger than the historical mean escapements (adult males plus females). The sum of the mean escapements for all stocks of 1.3 million adults was 18% of the corresponding estimates of the optimal escapement. The sum of the mean catches for all stocks of 5.1 million adults was 30% of the theoretical maximum catch of 16.7 million adults.

Stuart, Trembleur and Takla Lakes

Two runs to the Stuart, Trembleur and Takla lake systems are identified from run timing and spawning distribution. An early run (early Stuart) utilizes more than thirty small streams primarily on Takla Lake. The largest single spawning area in the early Stuart system is on the Driftwood River, the most northerly spawning habitat in the Fraser River watershed. The late run (late Stuart) utilizes a smaller number of streams on Stuart and Trembleur Lakes.

Although individuals spawning areas have dominant and off-cycle runs that are not necessarily in-phase, both the early and late Stuart runs were, collectively characterized by a dominant 1985 cycle. All other cycles, particularly in the late Stuart system, have been minor producers. Returns to the early Stuart (Fig. 3a) and late Stuart systems (Fig. 4a) have been highly variable with no trend in abundance since 1952.

Adult returns to the early Stuart system on the 1985 cycle ranged from 256,000 in 1965 to 1.4 million in 1973. The average 1952-85 return was

809,000/yr. Spawning escapements on the 1985 cycle averaged 208,000/yr and ranged from 23,000 in 1965 to 582,000 in 1949.

The fit of the Ricker model to data for the Early Stuart run was relatively good (σ=0.7) (Fig. 3b). However, because the early Stuart population spawn in approximately 30 different streams, the optimal escapement of 420,000 adults for all streams combined may not be representative. Several small streams on the early Stuart run were over-utilized in some years while the large spawning area on the Driftwood River was under-utilized. Low resolution of individual streams in the early Stuart fishery inhibits the ability to control escapements to these streams. Increasing production by re-distributing escapements amongst the early Stuart streams is therefore unlikely.

Despite an inability to control escapements to individual streams on the early Stuart system, the early Stuart run presents some unique opportunities for stock rebuilding. Collectively, the early Stuart run is the only Fraser River stock than does not co-migrate in significant numbers with other stocks. Since 1983 there has been a 50% reduction in the exploitation rates through fisheries management to increase escapement to the early Stuart system.

Adult returns to the late Stuart streams ranged from 606,000 in 1977 to 1.9 million in 1985. The average 1953-85 return was 1.3 million/yr. Escapements averaged 273,000 adults/yr. There is an extremely high level of uncertainty in the optimal escapement (662,000 adults) for the late Stuart run (σ=1.3) (Fig. 4b). There is a potential for increasing production to the late Stuart system, particularly on the off-cycles. However, there is much less ability to control escapements from the late Stuart run because the run-timing overlaps with other major stocks.

The Fraser-Francois (Nechako) system

Two spawning areas enumerated in the Nechako system are on the Nadina and Stellako rivers. The Nadina River historically supported an early and late run. The early run is now of minor importance and escapement estimates are included with estimates for the late run. The loss of the early run is believed to be the result of habitat degradation from logging (Williams pers. com.). A spawning channel designed for 14,000 females was constructed in on the Nadina River 1973 to increase utilization of the rearing area in Francois Lake (Cooper 1977). Most sockeye production since 1973 has been from the spawning channel. Returns to the Nadina River averaged 56,000/yr during 1952-85. The 1985 and 1987 cycles produced the largest returns, however, returns on the 1986 and 1988 cycles have increased since the early 1960s (Fig. 5a). Our estimate of the optimal escapement of 22,000 adults (Fig. 5b) is near the average for the 1985 and 1987 cycles.

The trend in production from the Stellako was relatively constant and averaged 419,000 returns/yr since 1952. The 1986 and 1987 cycles produced the major runs (Fig. 6a). Average returns on these cycles were 526,000/yr and 718,000/yr, respectively. Returns on the 1985 and 1988 cycles averaged 274,000/yr and 192,000/yr. Escapements to the Stellako averaged 75,000/yr. The estimate of optimal escapement for the Stellako of 295,000 adults was equal to the largest observed escapement. However, the largest escapement is an outlier on the recruitment curve (Fig. 6b). The true optimal escapement for the Stellako River may be larger.

Bowron River

The average 1952-85 returns from the Bowron River were 54,000 sockeye/yr. Four cycles of the 1987 run were a dominant feature on the Bowron River beginning in 1967. Interestingly, this occurred at the same as a decline in the abundance of the minor cycles (Fig. 7a). This is similar to a situation on the Raft River system (see North Thompson) where the 1988 cycle emerged as a dominant cycle, seemingly at the expense of the other cycles. The estimated optimal escapement of 30,000 adults may be an underestimate of the true level given the variability in the observed returns/spawner for the 1987 cycle (Fig. 7b).

Quesnel Lake

The main spawning areas are the Horsefly River and, to a lesser extent, the Mitchell River. The 1985 cycle has been the main contributor to the Quesnel Lake system. Returns to the Horsefly River on 1985 cycle increased exponentially from 476,000 in 1953 to 8.1 million returns in 1985. Returns to the 1986 cycle also increased with returns in 1986 of 514,000 sockeye (Fig. 8a). The large returns in 1985 resulted in a convex recruitment curve (exponential population growth) (Fig. 8b). As a result it was not possible to estimate the optimal estimate from the Ricker model. However, the increase in the returns/spawner suggests the Horsefly may support escapements in excess of 500,000 adults/yr. The adult escapement to the Horsefly River was 1.1 million in 1985. The largest production of sockeye in the Quesnel Lake system utilize spawning grounds on the Upper Horsefly River. There is also a large under-utilized spawning area on the Lower Horsefly River that has considerable potential for sockeye production.

The Mitchell River is the only other spawning area where escapements and returns were routinely measured. The trend in production from the Mitchell River is similar to the Upper Horsefly and the 1985 cycle is the only major run (Fig. 9a). Returns to the Mitchell have increased steadily from 7,000 returns in 1957 to 1.4 million returns in 1985. Because of the exponential population growth in the 1985 cycle, optimal escapement could not be estimated (Fig. 9b). However, the optimal is likely beyond the range of observed escapements and may exceed 200,000 adults.

Chilko Lake

Relatively large returns to the Chilko River occurred on the 1987 and 1988 cycles. Escapements on these cycles have been preserved at nearly equal strengths at averages of 473,000 and 309,000 adults/yr, respectively. Returns and exploitation rates on all four cycle years have remain relatively constant since 1952 (Fig. 10a). The 1988 cycle is the most important contributor to the Fraser River fishery on that cycle.

The fit of the Ricker model to the Chilko River data is comparatively good (σ=0.6) (Fig. 10b). The estimate of optimal escapement of 798,000 adults is beyond the 1948-85 range of observed adult escapement. The largest observed escapement occurred in 1948 and was 671,000 adults.

In the early 1960s a relatively small population of lake spawning sockeye was discovered at the south end of Chilko Lake. Estimates of escapement have been made annually since 1971. The estimates during most years were from mark-recapture experiments on dead (floating) carcasses and

are likely subject to large measurement errors. Estimates of adult escapement in 1984 were the largest since enumeration began at 128,000 adults. The estimate of optimal escapement for this stock (31,000 adults) is unreliable due to the short-time series and suspected measurement errors in the data.

South Thompson (Early runs)

Of the 13 early spawning runs to the South Thompson and Shuswap Lake systems, the runs to the Seymour River and Scotch Creek were routinely enumerated.

Returns on each of the four cycles to the Seymour River have shown little trend (Fig. 11a). Returns on the 1986 and 1987 cycles were consistently larger than the other two runs and averaged 222,000/yr and 169,000/yr, respectively. Returns on the 1988 and 1985 cycle averaged 26,000 and 33,000 adults/yr. The estimate of optimal escapement of 69,000 adults is larger than observed escapements on the Seymour River. However, escapements on the 1986 cycle were 63,000 adults on the last two returns of that cycle. Average escapements to the Seymour were 43,000 adults/yr on the 1986 cycle and 34,000/yr on the 1987 cycle. Escapements to the 1988 and 1985 cycles averaged 6,000 and 7,000 sockeye/yr. There has been a steady increase in escapements on the 1988 cycle from 4,000/yr in the 1950s to 11,000 since 1976. There were some extreme deviations from the recruitment curve (Fig 11b) but the fit of the model was relatively good (σ=0.8). Habitat degradation cause by logging in the Seymour watershed has been reported but the effect on recruitment is not known (Williams, pers com)

Returns and escapements to Scotch Creek were small compared to other Shuswap systems that are routinely enumerated (Fig. 12a). Returns on the 1985 and 1986 cycles averaged 26,000 and 14,000 sockeye/yr, respectively. Corresponding escapements averaged 5,000 and 1,000 adults/yr. Returns to the other two cycles have been negligible. There is large uncertainty in the estimated optimal escapement of 11,000 adults as reflected in the wide 95% confidence limits for the recruitment curve (σ=1.6) (Fig. 12b).

South Thompson (Late runs)

Of the 23 late spawning runs to the south Thompson River complex, the largest runs are to the lower Adams River and the lower Shuswap River. The lower Adams River population is the largest spawning population in the Fraser River system. Spawning escapement to the Lower Adams River were enumerated as a single complex that includes all other late Shuswap Lake runs except the Lower Shuswap system sockeye.

Estimates of returns to the Lower Adams complex averaged 2.1 million returns/yr since 1948. Returns were dominated by the 1986 cycle and, to a lesser extent, by the 1987 cycle. The average 1948-86 return were 6.8 million/yr on the 1986 cycle and 1.4 million/yr on the 1987 cycle. Returns on the 1985 and 1988 cycles were small in comparison and averaged 33,000 and 20,000/yr.

The 1958 escapement of 3.3 million was the largest on the 1986 cycle since 1948 and resulted in the lowest return for the cycle. Following the low returns of 1958 there was a steady increase in returns on the 1986 cycle from 2.9 million in 1968 to 8.2 million in 1982 (Fig. 13a). Escapements also increased over the same period from 1.1 million adults in 1962 to 2.5 million in 1982. Returns on the 1987 cycle increased at a similar rate as the 1986

cycle until 1971 when high exploitation reduced escapements to low levels. Since 1971, the 1987 cycle has shown modest increases.

There is considerable controversy surrounding the significance of the low returns per spawner from the 1958 brood. A fence was constructed at the outlet of the lower Adams River in 1958 to prevent over-escapement. The effect of the fence reportedly resulted in a large number of lake spawners and an unnaturally high egg mortality (Woodey, pers. com.). What ever the cause of the low returns per spawner, 1958 is an pivotal point in the stock-recruitment relationship (Fig. 13b). The estimate of the optimal escapement of 3.5 million is similar to the observed escapement in 1958. However, there is considerable uncertainty in this estimate. This is reflected in the wide 95% confidence limits for the recruitment curve and the relatively large residual standard deviation (σ=1.0).

Returns and escapements to the Lower Shuswap River increased substantially in the 1970s and 1980s. These increases occurred particularly on the 1986 cycle but also on the 1987 cycle (Fig. 14a). Returns on the 1986 cycle have increased from 50,000-126,000 in the 1950s and 1960s to 1.8 million in 1982. Escapements have increased accordingly, from under 20,000 in the 1950s to over 500,000 in 1982. There is little reliance in the estimates of optimal escapement. This is reflected in the extremely wide 95% confidence limits for the recruitment curve (Fig. 14b) and the large residual standard deviation (σ=?.0). The true optimal escapement is likely greater than 126,000 adults and, based on preliminary estimates of returns/spawner for the 1982 brood, may exceed 500,000 adults.

North Thompson

Catch and escapement data were collected from the Raft River and Fennel Creek. These systems support two small spawning populations. Beginning in 1972, the 1988 cycle for the Raft River emerged as dominant run (Fig. 15a). The increase on this cycle occurred at the same time as a decline in the abundance of the other three cycles despite no detectable trend in exploitation rates. There was a comparatively good fit of the Ricker model to data for the Raft River (σ=0.7) (Fig. 15b). Our estimate of optimal escapement of 14,000 adults is well above the 1952-85 mean of 6000 adults/yr.

Returns from Fennel Creek has increased from extremely low escapements in the 1950s and 1960s to a maximum of 73,000 adults in 1979 (Fig 16a). The average escapement since 1970 was 4,000 adults. There is considerable uncertainty in the relationship between stock and recruits (σ=1.0) and the optimal escapement may be greater than the 4900 adults estimated from the Ricker model (Fig. 16b).

Anderson and Seton Lakes

The major spawning areas in this system are Gates Creek and Portage Creek. A spawning channel designed for 9,000 females has been operational on Gates Creek since 1968. There was a marked increase in escapement and returns on all four cycles to both systems since the mid-1960s (Fig. 17a and Fig. 18a).

The 1988 cycle is the major producer on Gates Creek and averaged 71,000 adults/yr since 1952. The spawning channel has accounted for 95% of the total production since 1968. Estimates of optimal escapement for Gates Creek of 14,000 adults is near the long-term average for the 1988 cycle. The estimate

of optimal escapement may well be an underestimate caused by outliers in the stock-recruitment curve (Fig. 17b).

Production from Portage Creek was less dependent on a single strong cycle. The average return across all four cycles was of 26,000/yr. The 1986 cycle has produced the largest average return at 50,000/yr. Escapements to Portage Creek averaged 5,000 adults/yr and were considerably less than the estimated optimal of 14,000. The extremely wide 95% confidence limits on the recruitment curve (Fig. 18b) and the large residual standard deviation (σ=1.2) imply the optimal escapement is not well determined from the stock-recruitment relationship. The curve is unduly influenced by an extreme outlier and the optimal escapement is likely underestimated.

Lillooet and Harrison Lakes

The most important spawning areas are the Weaver Creek, Birkenhead River and Harrison River systems. A spawning channel that facilitates 30,000 females has been operational on Weaver Creek since 1965. Returns and escapements to the Weaver Creek (Fig. 19a) and Birkenhead River (Fig. 20a) have increased since that time on all cycles.

Returns from Weaver Creek were largest on the 1986 cycle and averaged 353,000 adults/yr since 1948 compared to an all-year average of 208,000 adults/yr. Spawning escapements averaged 36,000 adults/yr with an average of 64,000 adults/yr on the 1986 cycle. The estimated optimal escapement based on the Ricker model (Fig. 19b) was 54,000 sockeye.

Returns and escapements to the Birkenhead River during 1948-85 averaged 364,000 and 47,000/yr, respectively. Variations in return strength among the four cycles are less apparent on the Birkenhead River compared to other systems. The average return for all cycle years ranged from 280,000 to 515,000 sockeye/yr. The estimate of optimal escapement of 108,000 adults may underestimate the true optimal due to the effect of outliers on the recruitment model (Fig.20b).

Unlike the Weaver and Birkenhead systems, returns to the Harrison River system were relatively constant except for two years of large production in the 1950s (Fig 21a). The average returns were 44,000/yr during 1952-86. However, the rate of returns per spawner is extremely variable (Fig. 21b). Unlike other Fraser River systems, young sockeye from Harrison River have a very short period of freshwater residency (< 1 yr). The early influence of the marine environment on survival may account for the extreme variations in the observed returns per spawner.

Lower Fraser River

The two lower Fraser systems for which data have been collected are Cultus Lake and the Upper Pitt River. Returns for both systems have declined in recent years (Fig 23a and Fig. 24a). The decline was particularly pronounced on the Cultus Lake system since 1970.

For Cultus Lake, the average return was 11,000 adults/yr during 1974-85 compared to 113,000/yr during 1948-73. Escapements have also declined at a similar rate. Returns on the 1987 cycle have been the main producers with an average of 178,000/yr. The average for the other three cycles ranged from 33,000/yr to 100,000/yr. Cultus Lake returns on the 1988 cycle have averaged 45,000 adults/yr. The estimate of the optimal escapement for Cultus Lake of 80,000 adults is substantially higher than any recorded escapement since 1948.

Although there is uncertainty in the estimate using the Ricker model (Fig. 23b) (σ=1.0) it is clear than escapements in recent years were below the true optimal.

A small spawning channel (1,000 females) was completed in 1960 at the Upper Pitt River to halt a decline in abundance in the 1950s (Cooper 1977). Following a decline in exploitation rates, the abundance on all four cycles increased. The abundance is currently at low levels and has not responded to a decline in exploitation evident since 1977 (Fig.23a). The average return for the Upper Pitt River was 77,000/yr since 1948. The average escapement was 21,000 adults/yr compared to the estimated optimal escapement of 20,000 adults from the Ricker model (Fig.23b).

CONCLUSIONS AND RECOMMENDATIONS

There was considerable success at re-building returns of the major stocks on the dominant cycles since the collapse of upriver populations in the early 1900s. This was particularly evident for the Lower Adams and Shuswap Rivers and the Upper Horsefly River. Increases on the Birkenhead River and Weaver Creek also occurred. The Gates and Portage Creeks are two smaller systems that also increased in production.

The recent declines in returns from the Cultus Lake and Upper Pitt River systems warrants concern for lower Fraser River stocks. There are also upriver populations of historical significance that have remained at low levels, such as the Upper Adams and the Lower Horsefly rivers.

For many stocks there is considerable uncertainty in the correct stock-recruitment relationship and thus the estimates of optimal escapement. With few exceptions, the 95% confidence limits for the recruitment curve encompass a broad range of possible recruitment curves and imply a broad range of possible optimal escapements. This uncertainty is related to two phenomena. First, variability in stock-recruitment data caused by variable environmental effects on survival and measurement errors in the estimates of escapement and catch. Second, and most serious consideration, is the potential influence of year-class interaction and its effect on the cyclic variation observed for many Fraser River stocks. This analysis, and that of Walters and Staley (1987), show that the difference among recruitment curves could be due to biases in applying regression methods to short time-series of data where observed stock sizes are below the unfished equilibrium. Collie and Walters (1987) report the Ricker curve fails to account for year-class interactions and that with existing data neither the depensatory fishing nor depensatory predation hypotheses can be rejected as the cause of cyclic dominance. Until experiments are designed to address these issues the level of uncertainty in estimates of optimal escapement will remain high.

Environmental data was not encorporated in the present analysis. Environmental data may explain the large variation in recruits/spawner data. For example, flooding during egg incubation has reportedly effected survival, particularly on the Birkenhead, in some years (Williams, pers com). Anomalous temperature effects on survival has also been reported for other systems.

Estimates of production capacities derived from independent analysis need to been incorporated into assessment procedures. Estimates of spawning and rearing habits along estimates of optimal egg densities is a procedure currently under study (Williams, per com).

With the signing of the Canada-U.S. fishing treaty in 1985 there is now a greater benefit to Canadian fishermen to increase production of Fraser River sockeye. If a single spawner-return curve is appropriate then the stocks are being overfished and the opportunity for rebuilding the off cycles is tremendous. The potential for rebuilding stocks cannot be ignored. The greatest opportunity lies in re-building off-year runs of the major systems such as the Horsefly River and the Upper and Lower Adams River. The focus of re-building strategies should maximize natural production by increasing escapement levels through fisheries intervention. Enhancement techniques such as spawning channels and lake enrichment should also being considered. However, for most systems spawning habitat appears to be the limiting factor (Williams pers. com).

The level of allowable harvests needed to re-build the Fraser system is a function of the rate and amount of re-building as well as on the specific stocks targeted for re-building. The rate of re-building will be largely dependent on the willingness of the fishing industry to reduce the catch in the face of uncertainties in future production. The stocks with the greatest potential may not necessarily be the ones most easily regulated. There will be a need to develop an in-season plan that allows us to take advantage of those stocks with the greatest potential for re-building.

The most obvious uncertainty in re-building off-year runs is the effect of year-class interaction. It is essential to develop re-building plans in concert with an experimental design that can be used to identify factors influencing productivity.

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Table 1. Methods used to estimate spawning escapements of Fraser River sockeye.

Stream type	Enumeration method
Large population (>25000), closed system	Petersen, sexes separate
Large population, but few jacks	Petersen, sexes separate for males and females, but jacks by dead recovery x availability factor x male dead recovery
Large population, strays to other streams	Petersen, sexes separate, but subtract stray tags from tags available
Large population in a complex of streams where not possible to perform tagging study on separate streams due to high degree of straying	Petersen, sexes separate on the complex, subtract out populations of streams with separate enumeration, then allocate population to remaining streams by dead recovery
Medium population (<25000), poor recovery of either sex	Petersen, sexes combined (not commonly used)
Medium population, or large population but limited access to stream	(Peak live count + cumulative dead) x factor
Medium population, closed system	Dead recovery x factor
Spawning Channel	Total dead recovery

Table 2. Estimates of Ricker stock-recruitment biased and biased corrected parameters caused from time series bias. Parameter estimates were determined for all years of data and for each cycle year where sufficient data were available. The parameter b was multiplied by 10^6.

	a			b		
Stock	biased	bias corrected	% error	biased	bias corrected	% error
Early Stuart						
all years	2.441	2.407	1.39	4.878	3.919	19.66
1984 cycle	2.834	2.777	2.01	62.287	51.506	17.31
1985 cycle	3.237	3.172	2.01	9.673	8.987	7.09
1986 cycle	2.656	2.567	3.35	39.246	36.761	6.33
1987 cycle	3.221	3.163	1.80	37.390	30.062	19.60
Late Stuart						
all years	2.757	2.698	2.14	4.496	2.834	36.97
1984 cycle	4.256	4.115	3.31	1176.723	1170.22	0.55
1985 cycle	3.420	3.400	0.58	8.102	1.284	84.15
1986 cycle	3.750	3.711	1.04	205.178	204.191	0.48
1987 cycle	3.540	3.529	0.31	243	242.457	0.22
Late Nadina[a]						
all years	3.2675	3.250	0.54	87.550	82.080	0.062
Stellako						
all years	2.656	2.613	1.62	6.872	5.839	15.03
1984 cycle	2.990	2.894	3.21	24.812	21.055	15.14
1985 cycle	2.938	2.888	1.70	35.814	34.449	3.81
1986 cycle	2.264	1.993	11.97	-1.441	-7.501	-420.54
1987 cycle	3.344	3.208	4.07	12.472	10.66	14.53
Bowron						
all years	2.672	2.631	1.53	66.646	59.174	11.21
1984 cycle	2.780	2.705	2.70	102.405	86.469	15.56
1985 cycle	2.186	2.111	3.43	27.584	10.279	62.74
1986 cycle	3.081	3.037	1.43	199.549	193.394	3.08
1987 cycle	4.156	4.186	-0.72	161.944	162.35	-0.25
Horsefly[b]						
all years	2.786	2.753	1.18	-0.879	-4.789	-444.82
1984 cycle	3.802	3.745	1.50	10401.72	9799.556	5.79
1985 cycle	3.058	2.997	1.99	2.744	2.002	27.04
1986 cycle	2.707	2.273	16.03	5.279	-387.41	7438.70
1987 cycle	3.150	3.150	0.00	1496.939	-819.638	154.75
Mitchell[b]						
all years	2.537	2.537	0.00	-49.796	-51.457	-3.34

Table 2 (cont'd)

Stock	a biased	a bias corrected	a % error	b biased	b bias corrected	b % error
Chilko River						
all years	2.542	2.518	0.94	2.016	1.860	7.74
1984 cycle	3.023	2.965	1.92	3.507	3.290	6.19
1985 cycle	2.491	2.283	8.35	12.543	8.548	31.85
1986 cycle	3.590	3.643	-1.48	16.095	16.406	-1.93
1987 cycle	2.953	2.813	4.74	3.985	3.109	21.98
Early Chilko						
all years	3.424	3.459	-1.02	59.26	59.000	0.44
Seymour						
all years	2.719	2.674	1.66	25.154	25.333	-0.71
1984 cycle	3.069	3.057	0.39	315.856	286.460	9.31
1985 cycle	3.395	3.273	3.59	308.245	282.295	8.42
1986 cycle	3.904	3.845	1.51	63.078	60.733	3.72
1987 cycle	3.857	3.891	-0.88	90.066	89.062	1.11
Scotch						
all years	3.168	3.119	1.55	217.46	164.420	24.39
Lower Adams						
all years	2.380	2.342	1.60	0.644	0.402	37.58
1984 cycle	2.709	2.735	-0.96	243.944	245.930	-0.81
1985 cycle	4.325	4.369	-1.02	816.263	816.759	-0.06
1986 cycle	3.257	3.221	1.11	1.531	1.660	-8.43
1987 cycle	2.532	2.529	0.12	1.886	-1.064	156.42
Lower Shuswap						
all years	3.318	3.291	0.81	15.250	14.175	7.05
Raft[b]						
all years	2.746	2.704	1.53	154.088	137.131	11.00
1984 cycle	3.341	3.235	3.17	229.700	212.412	7.53
1985 cycle	2.833	2.717	4.09	279.704	164.738	41.10
1986 cycle	2.481	2.208	11.00	107.018	34.656	67.62
1987 cycle	2.865	2.888	-0.80	241.995	233.007	3.71
Fennell						
all years	3.545	3.531	0.39	412.083	390.670	5.48
Weaver						
all years[a]	3.448	3.428	0.58	33.293	32.411	2.65

Table 2 (cont'd)

Stock	a biased	a bias corrected	a % error	b biased	b bias corrected	b % error
Birkenhead						
all years	3.053	3.012	1.34	17.599	16.226	7.80
1984 cycle	2.844	2.766	2.74	18.937	16.686	11.89
1985 cycle	3.195	3.103	2.88	25.106	23.316	7.13
1986 cycle	3.022	2.971	1.69	9.737	8.014	17.70
1987 cycle	3.575	3.496	2.21	35.853	34.636	3.39
Harrison						
all years	2.983	2.973	0.34	146.356	145.394	0.66
1984 cycle	2.632	2.624	0.30	129.928	102.088	21.43
1985 cycle	2.820	2.698	4.33	191.140	107.516	43.75
1986 cycle	2.857	2.862	-0.18	125.719	136.040	-8.21
1987 cycle	4.181	4.162	0.45	199.055	191.267	3.91
Portage						
all years	3.409	3.393	0.47	207.219	198.257	4.32
1984 cycle	4.370	4.208	3.71	2037.570	1785.962	12.35
1985 cycle	3.152	3.080	2.28	140.585	134.667	4.21
1986 cycle	3.326	3.347	-0.63	170.598	170.612	-0.01
1987 cycle	4.190	4.773	-13.91	1007.962	1053.876	-4.56
Gates[a]						
all years	3.643	3.642	0.03	175.565	174.863	0.40
Upper Pitt[a]						
all years	3.233	3.233	0.00	123.358	123.362	-0.00
Cultus						
all years	2.280	2.229	2.24	23.856	18.061	24.29
1984 cycle	2.051	1.857	9.46	40.730	-19.449	147.75
1985 cycle	2.512	2.255	10.23	120.639	117.408	2.68
1986 cycle	2.340	2.396	-2.39	16.040	16.121	-0.50
1987 cycle	3.444	3.482	-1.10	68.617	68.762	-0.21

a: estimates are for data collected since completion of spawning channels; Late Nadina - 1973, Upper Pitt - 1960, Weaver - 1965, Gates - 1968.

b: negative parameter estimates imply exponential population growth (convex curve).

Table 3. Estimates of biased Ricker parameters in cycle years from Monte Carlo simulations using the all-year parameter estimates as the "true" values for each cycle year. The parameter b was multiplied by 10^6.

Stock	Ricker a	Ricker b	Optimal Escapement (eff. females)
Early Stuart			
all years	2.4415	4.8777	172400
1984 cycle	2.5898	15.2725	56000
1985 cycle	2.6099	28.9825	29700
1986 cycle	2.4798	6.4369	131500
1987 cycle	2.7113	16.1338	54000
Late Stuart			
all years	2.7571	4.4962	207500
1984 cycle	3.0832	9995.9542	100
1985 cycle	3.0418	10.1897	92500
1986 cycle	3.0701	58.3307	16200
1987 cycle	3.0647	88.3722	11000
Stellako			
all years	2.656	6.8724	124800
1984 cycle	2.853	15.3991	57000
1985 cycle	2.9426	16.9973	52300
1986 cycle	2.9243	14.6422	60500
1987 cycle	2.8327	11.4033	77000
Bowron			
all years	2.6724	66.6457	13000
1984 cycle	2.8084	92.6617	9500
1985 cycle	2.7849	93.7779	9400
1986 cycle	2.8817	106.4822	8300
1987 cycle	2.8222	109.9476	8000
Chilko River			
all years	2.5419	2.0161	419700
1984 cycle	2.7516	5.421	160300
1985 cycle	2.7482	2.9408	296000
1986 cycle	2.8396	7.6499	115000
1987 cycle	2.7655	10.5134	83000
Seymour			
all years	2.7188	30.3546	29100
1984 cycle	2.9655	63.7236	14200
1985 cycle	2.8942	104.9468	8500
1986 cycle	2.9596	50.9126	17700
1987 cycle	2.9116	70.9853	13000

Table 3 (cont'd)

Stock	Ricker a	Ricker b	Optimal Escapement (eff. females)
Adams River			
all years	2.3824	0.6662	1311400
1984 cycle	2.7656	6.3061	143600
1985 cycle	2.8342	14.6103	62200
1986 cycle	2.4466	0.678	1288500
1987 cycle	2.5946	1.0738	830000
Raft			
all years	2.7461	154.0879	5700
1984 cycle	2.9132	288.4611	3100
1985 cycle	2.9017	230.8504	3900
1986 cycle	2.9798	297.4524	3000
1987 cycle	2.9297	218.0276	4000
Birkenhead			
all years	3.0532	17.599	51300
1984 cycle	3.278	25.7855	35700
1985 cycle	3.0833	18.3112	49400
1986 cycle	3.12	19.9839	45400
1987 cycle	3.1501	18.973	48000
Cultus			
all years	2.2801	23.8556	35000
1984 cycle	2.4351	70.5389	12100
1985 cycle	2.4931	53.6174	16000
1986 cycle	2.4381	50.0295	17000
1987 cycle	2.4684	43.1622	20000

Table 4. Autocorrelations of residuals for Fraser River sockeye.

Lag (yr)	Chilko River	Upper Horsefly	Raft	Lower Adams	Lower Shuswap
1	0.097	-0.176	0.111	0.170	-0.173
2	-0.111	-0.008	-0.249	-0.019	-0.069
3	-0.125	0.033	0.172	-0.203	0.177
4	0.148	-0.316	0.140	-0.160	0.296
5	0.072	-0.057	-0.091	-0.150	-0.239
6	-0.148	0.011	0.039	-0.245	0.129
7	-0.366	0.042	-0.202	-0.082	0.042
8	0.079	0.217	-0.409	-0.010	-0.110

Lag (yr)	Seymour	Early Stuart	Late Stuart	Stellako	Bowron
1	0.008	0.254	0.147	-0.220	0.232
2	-0.224	0.318	0.182	-0.300	-0.022
3	-0.050	0.033	0.256	0.173	0.106
4	-0.101	0.213	0.011	-0.028	0.100
5	0.207	0.001	-0.042	-0.037	-0.211
6	-0.088	0.008	-0.100	-0.017	-0.215
7	-0.041	-0.192	-0.172	-0.080	-0.121
8	0.045	0.020	-0.395	0.214	-0.148

Lag (yr)	Birken-Head	Harrison	Weaver	Cultus	Upper Pitt
1	0.180	0.125	-0.001	0.180	0.133
2	0.042	-0.230	0.126	0.043	0.037
3	0.032	-0.143	-0.273	0.094	0.124
4	0.099	0.115	-0.274	-0.029	-0.071
5	0.116	-0.115	-0.212	-0.056	-0.030
6	-0.068	-0.073	-0.053	-0.344	-0.258
7	0.016	0.261	0.002	-0.165	0.075
8	0.091	0.214	0.213	-0.093	0.009

Lag (yr)	Gates	Portage
1	0.240	0.021
2	0.150	0.013
3	0.155	-0.238
4	-0.013	-0.234
5	-0.161	-0.112
6	0.020	-0.218
7	-0.317	0.191
8	-0.233	0.069

Table 5. Estimates of biased and bias corrected equilibrium stock size and optimal escapements of adult Fraser River sockeye.

Stock	Equilibrium stock (effective females)		Optimal escapement (effective females)	
	biased	bias corrected	biased	bias corrected
Early Stuart				
all years	500538	614270	165093	204042
1984 cycle	45491	53922	13822	16579
1985 cycle	334632	352900	93359	99826
1986 cycle	67678	69835	21345	22439
1987 cycle	86149	105201	24115	29815
Late Stuart				
all years	613217	951858	189339	297597
1984 cycle	3617	3517	818	818
1985 cycle	422163	2648497	113320	714016
1986 cycle	18279	18176	4581	4592
1987 cycle	14567	14555	3814	3819
Late Nadina				
all years	37322	39591	10345	11016
Stellako[a]				
all years	386474	447425	121893	142407
1984 cycle	120494	137445	35421	41231
1985 cycle	82022	83839	24379	25180
1986 cycle	-1571117	-265648	-537440	-95978
1987 cycle	268129	300952	73136	84476
Bowron				
all years	40098	44457	12604	14096
1984 cycle	27150	31286	8342	9766
1985 cycle	79235	205377	27542	72470
1986 cycle	15439	15702	4452	4570
1987 cycle	25662	25781	5922	5915
Horsefly[a]				
all years	-3170714	-574852	-973123	-177657
1984 cycle	366	382	91	96
1985 cycle	1114333	1497057	322905	439416
1986 cycle	512825	-5867	160010	-2003
1987 cycle	2104	-3843	598	-1092
Mitchell[a]				
all years	-50948	-47976	-16474	-15529

Table 5 (cont'd)

Stock	Equilibrium stock (effective females) biased	Equilibrium stock (effective females) bias corrected	Optimal escapement (effective females) biased	Optimal escapement (effective females) bias corrected
Chilko River				
all years	1260790	1353760	407257	439444
1984 cycle	861924	901094	251587	266285
1985 cycle	198589	267110	64834	91017
1986 cycle	223062	222025	57785	56894
1987 cycle	740867	904788	219504	276116
Early Chilko				
all years	57779	58627	15496	15609
Seymour				
all years	89570	105307	27880	33132
1984 cycle	9717	10671	2809	3093
1985 cycle	11015	11595	2972	3210
1986 cycle	61893	63309	15029	15559
1987 cycle	42828	43692	10499	10637
Scotch				
all years	14489	14499	4094	4096
Lower Adams[b]				
all years	3575941	5389808	1193965	1817351
1984 cycle	11104	11122	3464	3450
1985 cycle	5298	5349	1183	1184
1986 cycle	2127992	1940560	591122	543274
1987 cycle[a]	1342418	-2376788	434498	-769868
Lower Shuswap				
all years	217338	215248	59588	54922
Raft				
all years	17822	19150	5515	5972
1984 cycle	14546	15227	3970	4251
1985 cycle	10128	16490	3078	5135
1986 cycle	23185	63699	7584	22043
1987 cycle	11840	12394	3573	3723
Fennell				
all years	8577	8574	2243	2242
Weaver[c]				
all years	103560	107177	27637	28879

Table 5 (cont'd)

Stock	Equilibrium stock (effective females) biased	Equilibrium stock (effective females) bias corrected	Optimal escapement (effective females) biased	Optimal escapement (effective females) bias corrected
Birkenhead				
all years	173488	175917	50318	51179
1984 cycle	150193	165790	45530	51090
1985 cycle	127275	133098	35822	38197
1986 cycle	310318	370690	90610	109405
1987 cycle	99709	100940	25913	26668
Harrison				
all years	20384	20450	6000	6032
1984 cycle	20260	25702	6422	8161
1985 cycle	14754	25092	4495	7845
1986 cycle	22726	21037	6871	6354
1987 cycle	21006	21760	4823	5016
Portage				
all years	16431	17276	4417	4641
1984 cycle	2145	2356	474	538
1985 cycle	22420	22873	6368	6596
1986 cycle	19494	19616	5338	5347
1987 cycle	4157	4529	953	928
Gates[c]				
all years	20752	20829	5317	5338
Upper Pitt[c]				
all years	26210	26205	7318	7318
Cultus[a]				
all years	95579	123423	32590	42524
1984 cycle	50353	-95487	17983	-35428
1985 cycle	20823	19206	6768	6583
1986 cycle	145864	148628	49133	49485
1987 cycle	50188	50642	13406	13418

a : Negative values are the result of parameter estimation. The Ricker stock-recruitment curve for these stocks is convex and implies the optimal escapement is beyond the observed escapements.

b : Lower Adams includes the Lower Adams River, Little River and Late Seymour River.

c : Estimates are for data collected since completion of spawning channels; Late Nadina - 1973, Upper Pitt - 1960, Weaver - 1965; Gate - 1968.

Table 6. Mean adult escapements (1948-85), the estimated optimal escapement, the mean historical adult catch, the estimated maximum catch and the standard deviation of the regression for Fraser River sockeye.

Stock	Mean Escapement	Optimal Escapement	Mean Catch	Maximum[a] Catch	Standard[b] Deviation
Early Stuart	76909	420270	220734	606120	0.689
Late Stuart	79414	662370	292169	1260240	1.327
Nadina	9080	21630	46450	93670	0.854
Stellako	15754	294850	343232	554170	0.551
Bowron	11355	30030	42475	55410	0.659
Horsefly[c]	101806	500000	493169	3400000	–
Mitchell[c]	16808	200000	99292	1100000	–
Chilko River	245948	797670	992388	1622040	0.594
Chilko Lake	23664	31020	71216	166950	1.052
Seymour	22339	69380	85822	140910	0.773
Scotch	2491	11460	11027	39110	1.574
Lower Adams	474520	3450480	1602828	5794480	1.043
Lower Shuswap	32299	125500	84647	571560	1.588
Raft	6333	13920	23218	25820	0.714
Fennell	2586	48790	7100	272500	0.98
Weaver	35591	53990	172744	295020	0.71
Birkenhead	46807	107960	317594	350470	0.587
Harrison	14463	12590	29967	36710	0.966
Portage	4530	9480	21318	45700	1.448
Gates	4912	13560	18992	66710	1.452
Upper Pitt	20606	14520	56886	60940	0.986
Cultus	14374	79670	71466	106390	0.839
Total	1262589	6969140	5104734	16664920	

a: The maximum catch is the theoretical maximum catch achieved at the optimal escapement assumming a single spawner-return curve is appropriate. It was calculated from the Ricker model from the equation $C = S^{*}\exp(a-bS^{*} + \sigma^2/2) - S^{*}$; where C is the maximum catch.

b: The standard deviation is σ from the Ricker model and is shown here as an index of the relative reliance in the optimal escapement and maximum catch.

c: Optimal escapements were not determined from Ricker model because of exponential growth. Estimates of the optimal escapement and maximum catch were determined from the last observed escapement resulting in an increase in returns and from the mean (1948-81) returns per spawner.

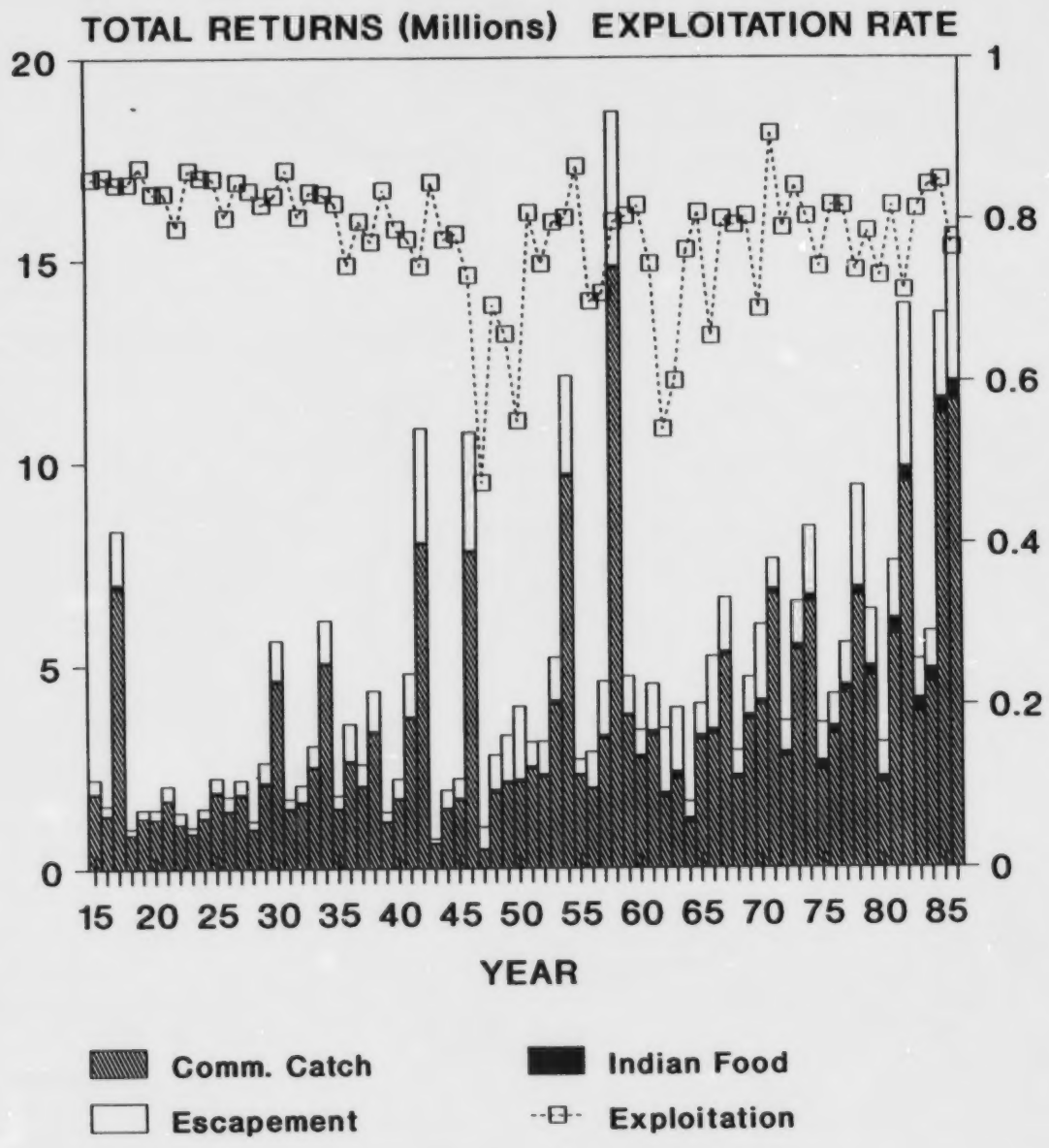

Fig. 1. Adult Returns, catch, escapement and exploitation of Fraser River sockeye, 1915-86 (source: 1915-51 - Killick and Clemens (1963) 1952-86 - IPSFC data).

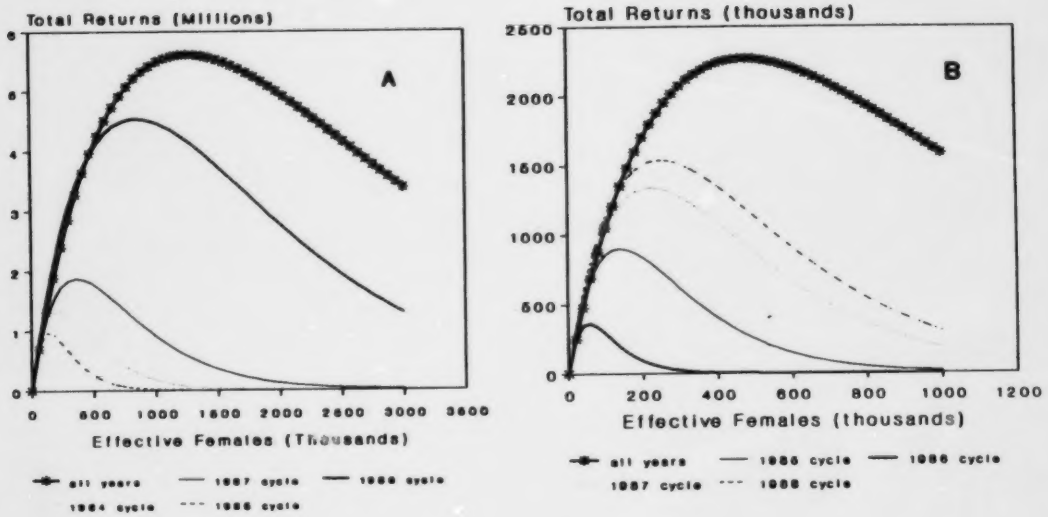

Fig. 2. Results from Monte Carlo simulations (n=1000) showing potential time series bias when fitting Ricker models to cycle years data when the all-years assumption is true for A) Lower Adams River and B) Chilko River.

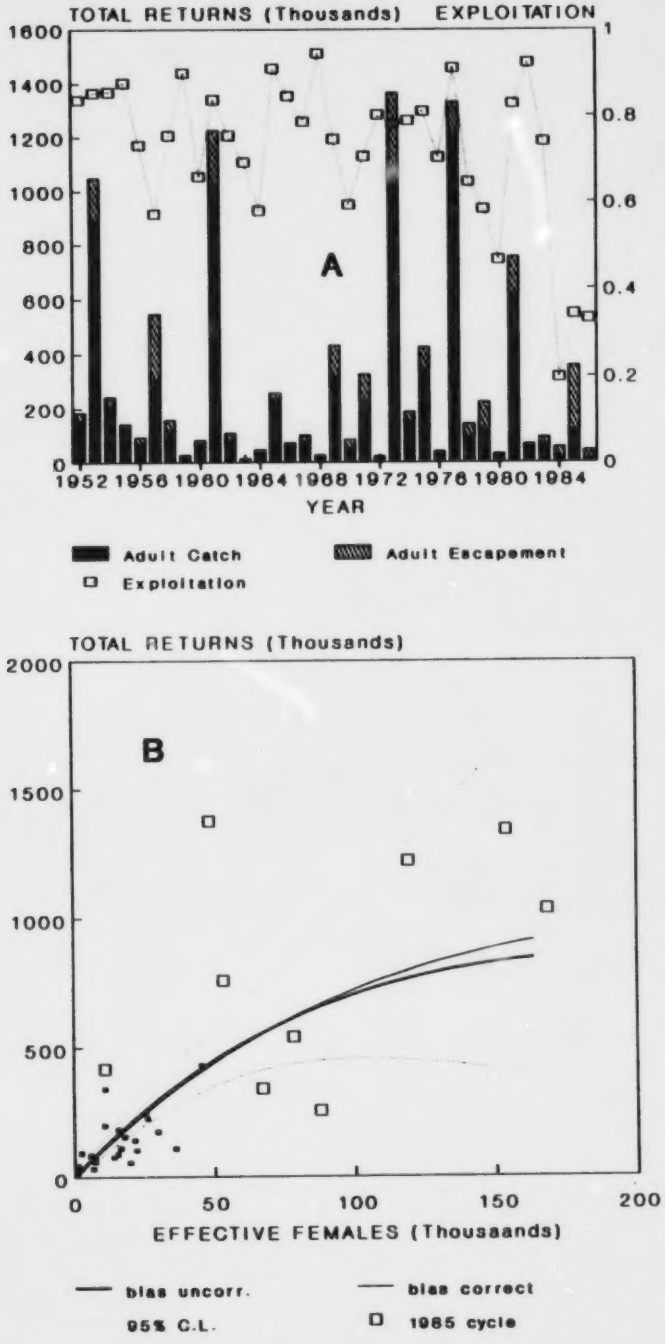

Fig. 3. A) Returns, catch, escapement and exploitation rate and B) the Ricker stock-recruitment relationship for Early Stuart sockeye.

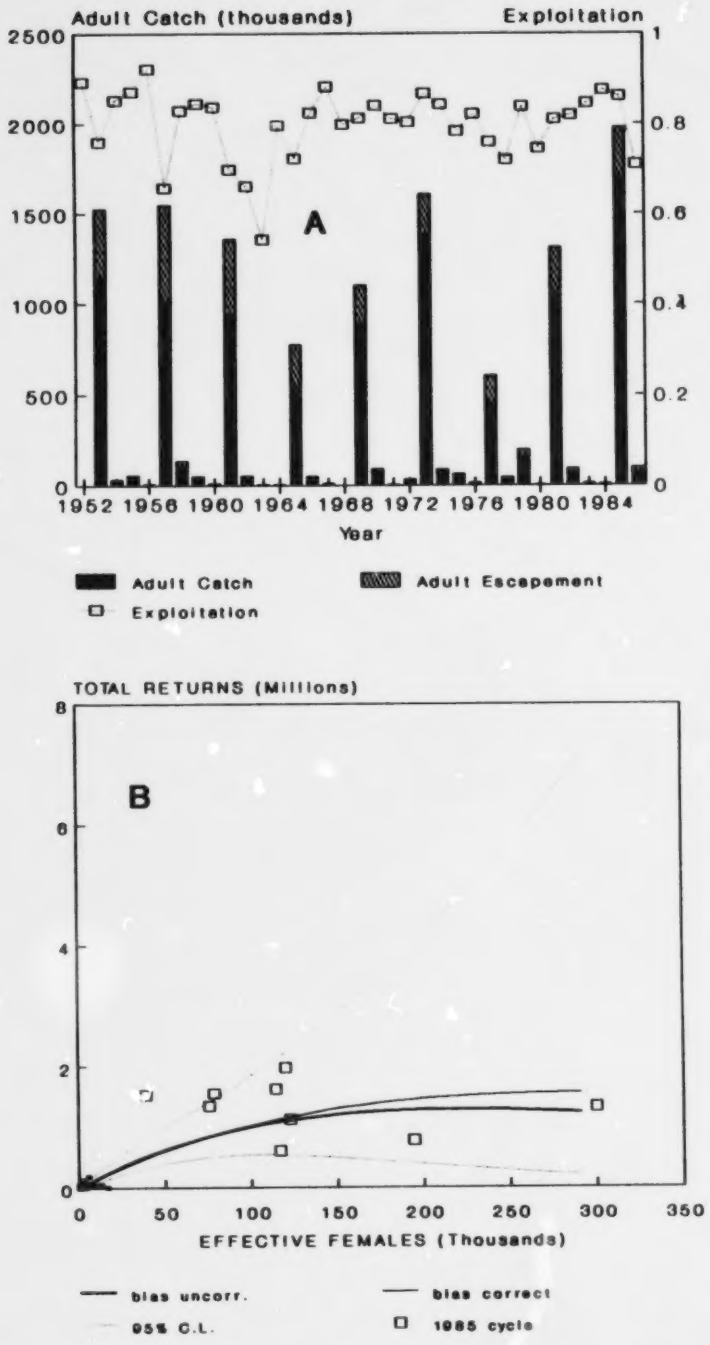

Fig. 4. A) Returns, catch, escapement and exploitation rate and B) the Ricker stock-recruitment relationship for Late Stuart sockeye.

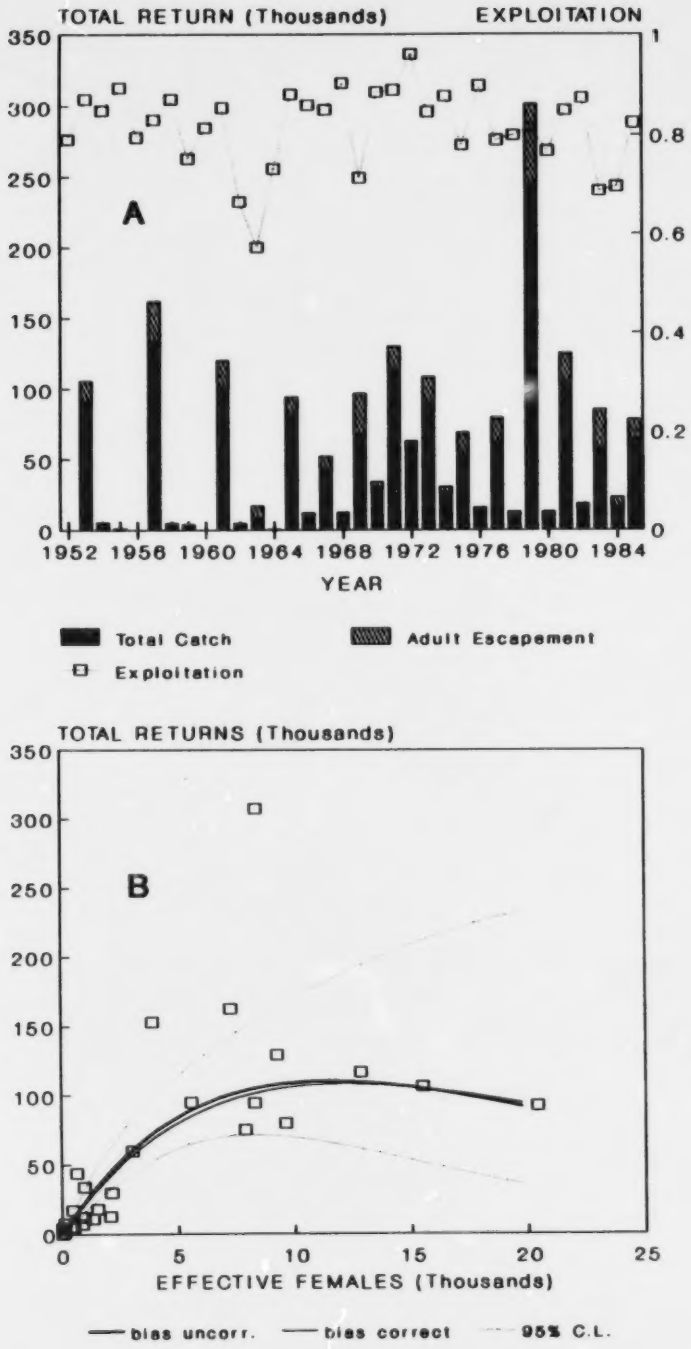

Fig. 5. A) Returns, catch, escapement and exploitation rate and B) the Ricker stock-recruitment relationship for Nadina River sockeye.

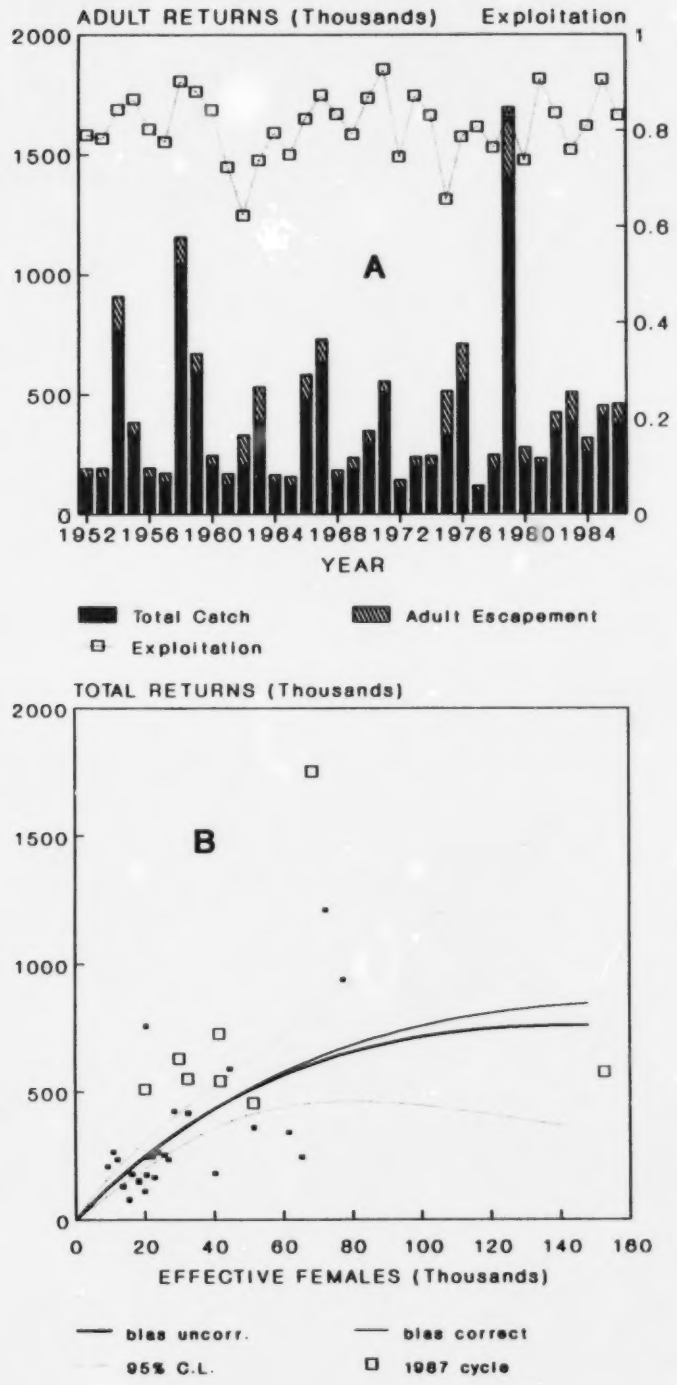

Fig. 6. A) Returns, catch, escapement and exploitation rate and B) the Ricker stock-recruitment relationship for Stellako River sockeye.

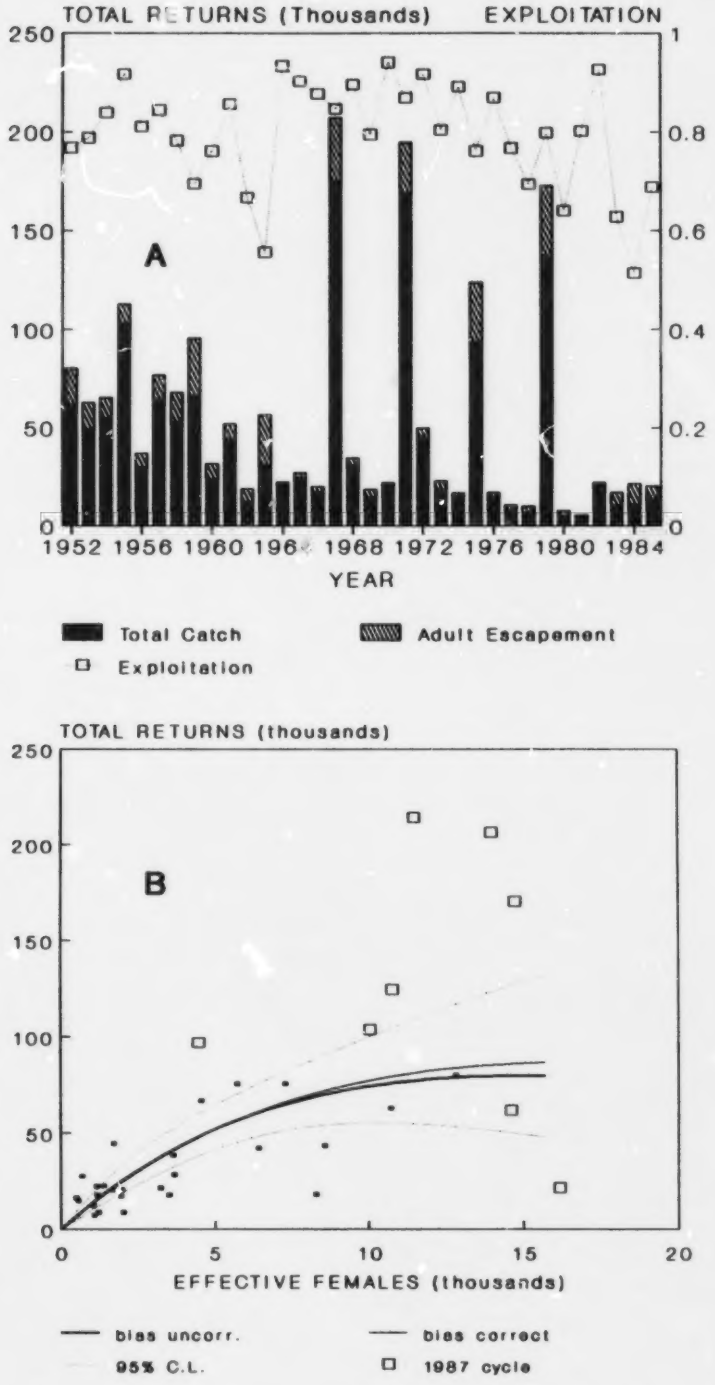

Fig. 7. A) Returns, catch, escapement and exploitation rate and B) the Ricker stock-recruitment relationship for Bowron River sockeye.

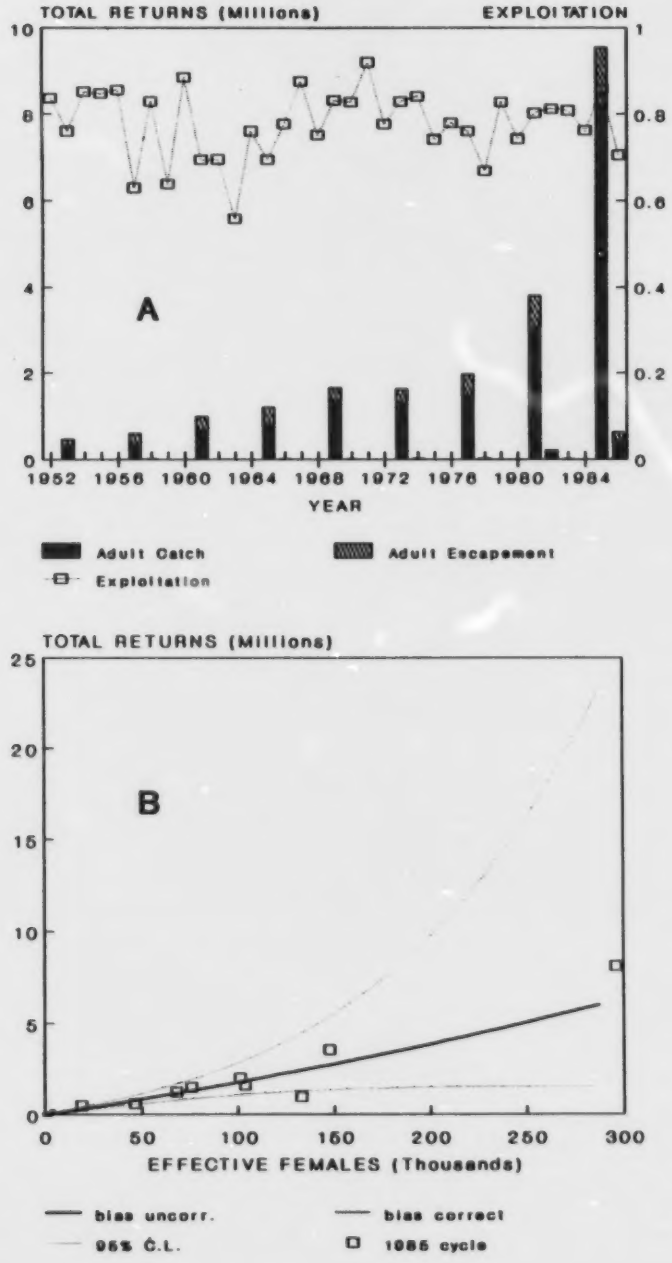

Fig. 8. A) Returns, catch, escapement and exploitation rate and B) the Ricker stock-recruitment relationship for Horsefly River sockeye.

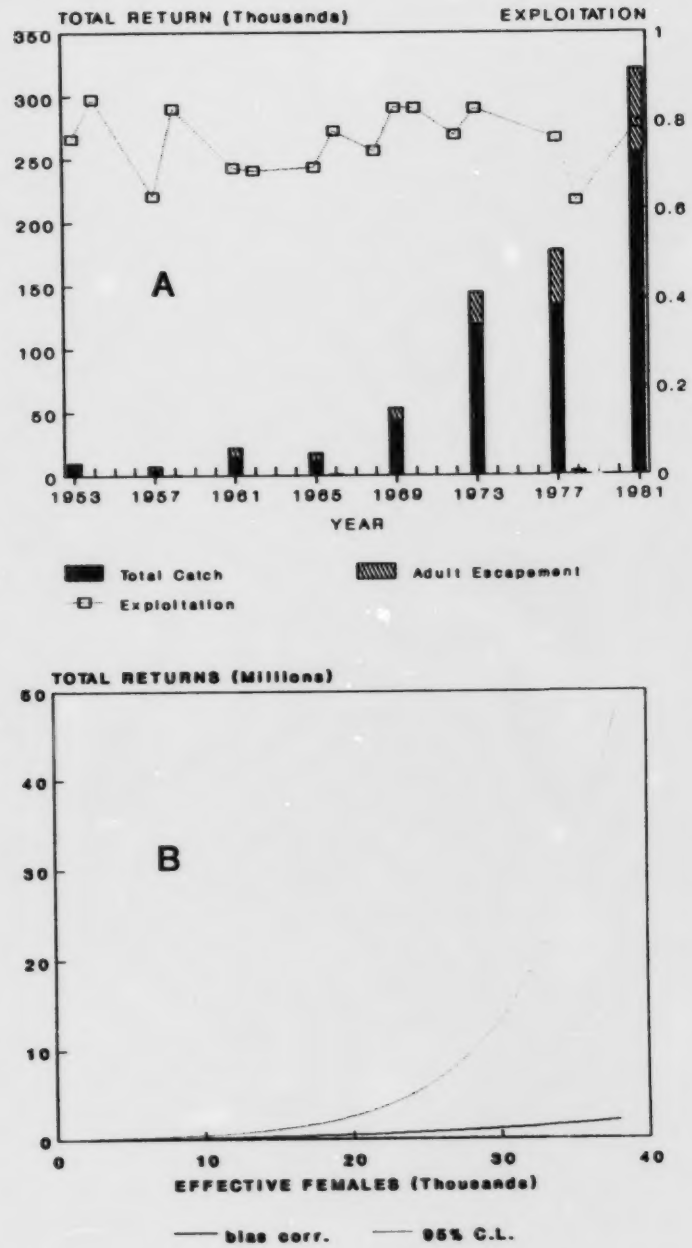

Fig. 9. A) Returns, catch, escapement and exploitation rate and B) the Ricker stock-recruitment relationship for Mitchell River sockeye.

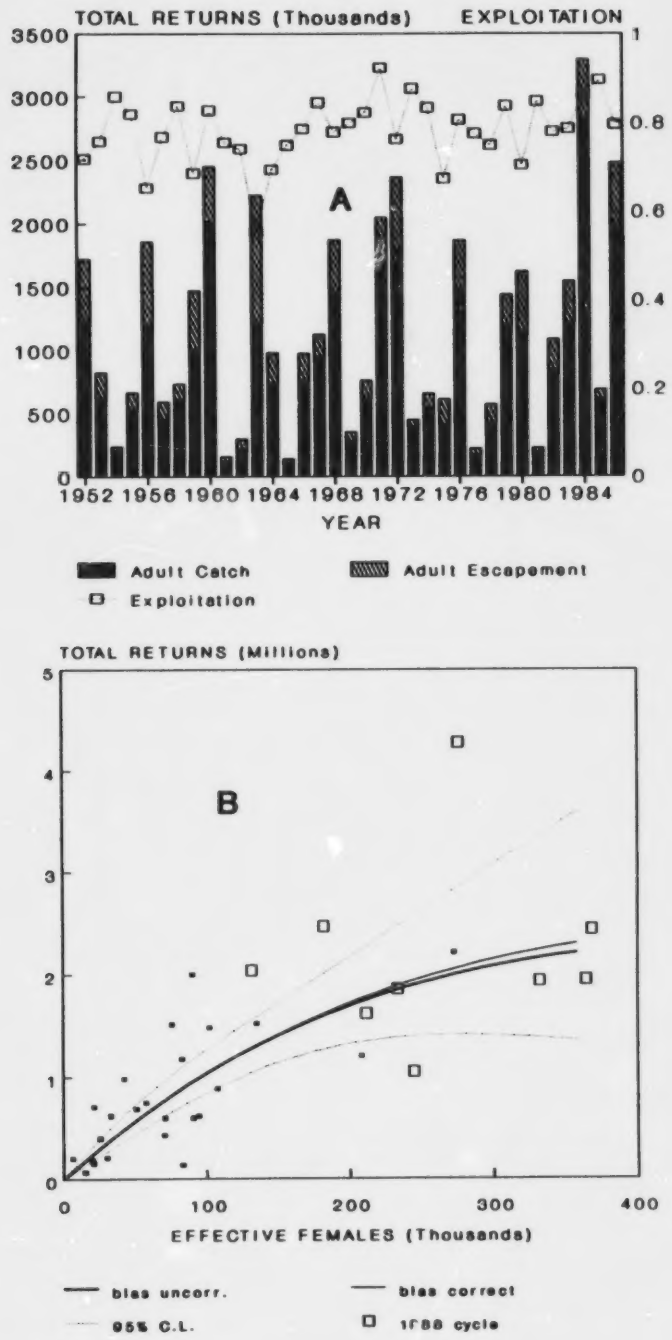

Fig. 10. A) Returns, catch, escapement and exploitation rate and B) the Ricker stock-recruitment relationship for Chilko River sockeye.

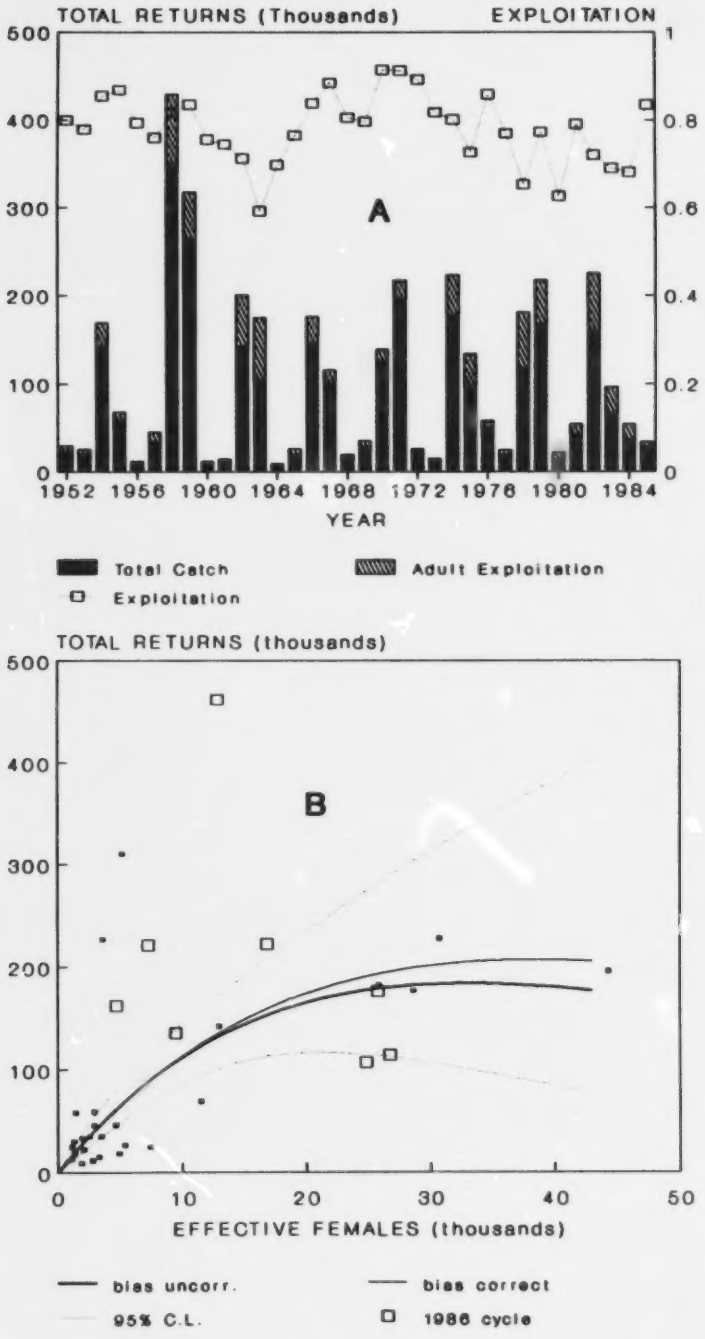

Fig. 11. A) Returns, catch, escapement and exploitation rate and B) the Ricker stock-recruitment relationship for Seymour River sockeye.

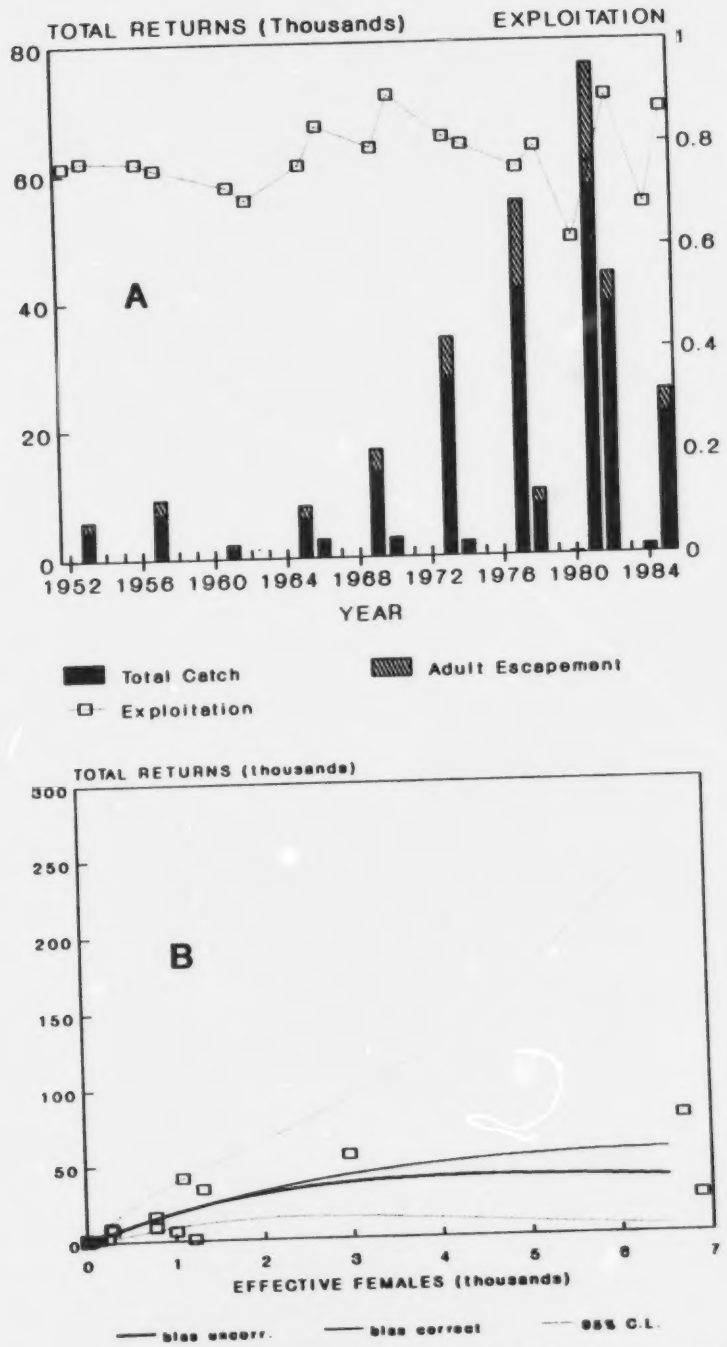

Fig. 12. A) Returns, catch, escapement and exploitation rate and B) the Ricker stock-recruitment relationship for Scotch Creek sockeye.

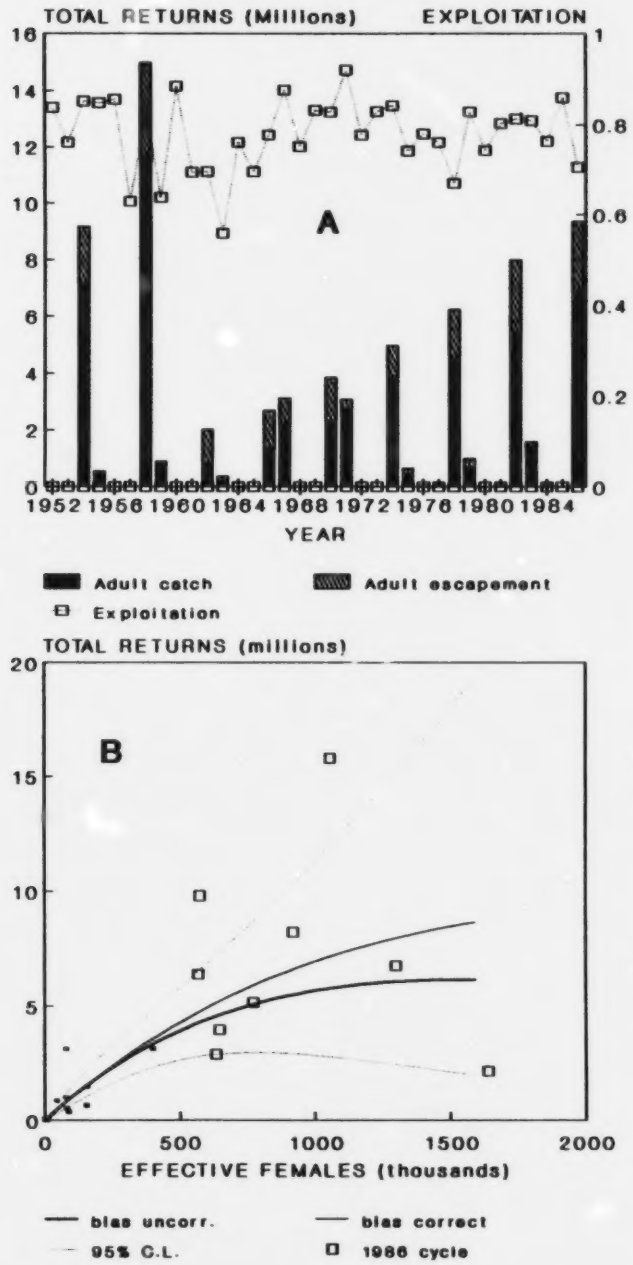

Fig. 13. A) Returns, catch, escapement and exploitation rate and B) the Ricker stock-recruitment relationship for Lower Adams sockeye.

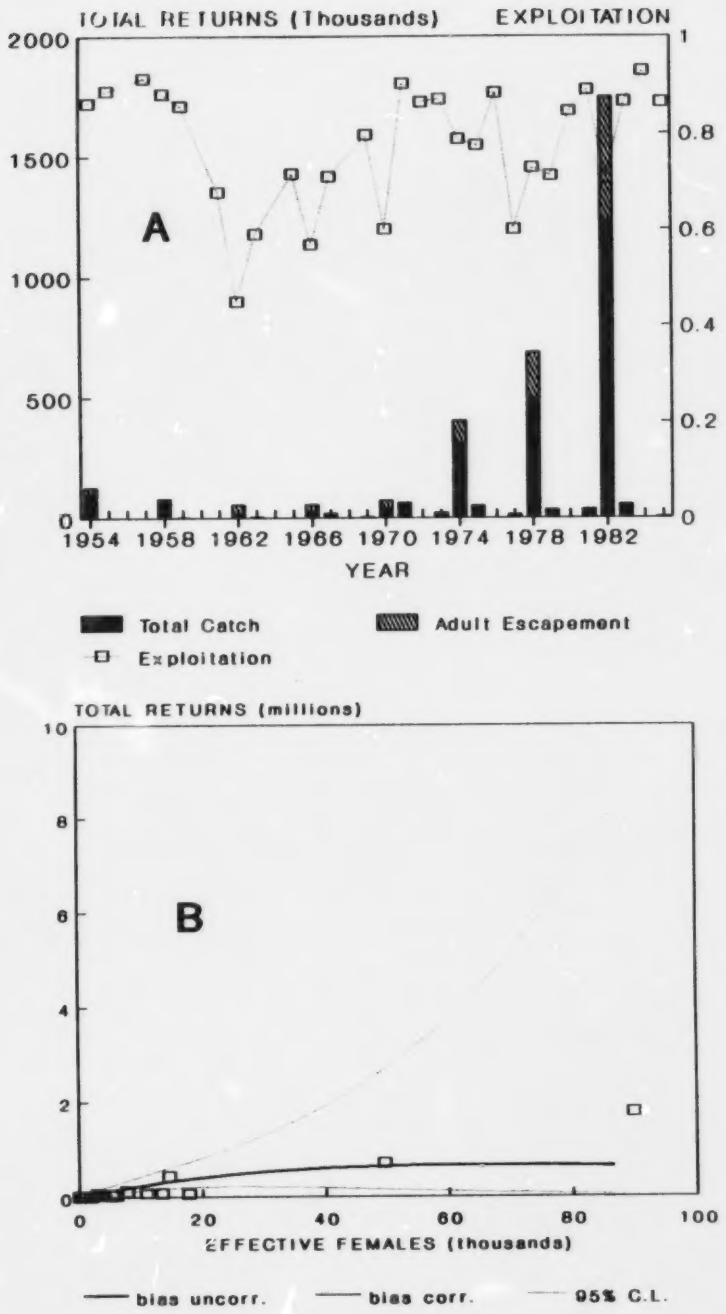

Fig. 14. A) Returns, catch, escapement and exploitation rate and B) the Ricker stock-recruitment relationship for Lower River Shuswap sockeye.

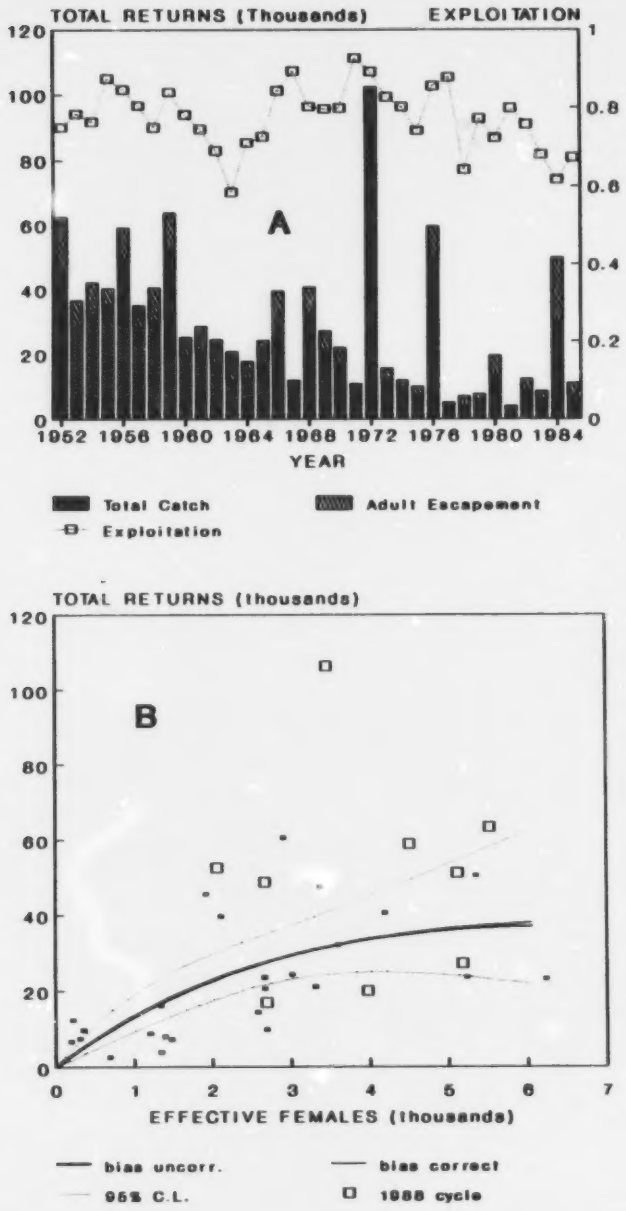

Fig. 15. A) Returns, catch, escapement and exploitation rate and B) the Ricker stock-recruitment relationship for Raft River sockeye.

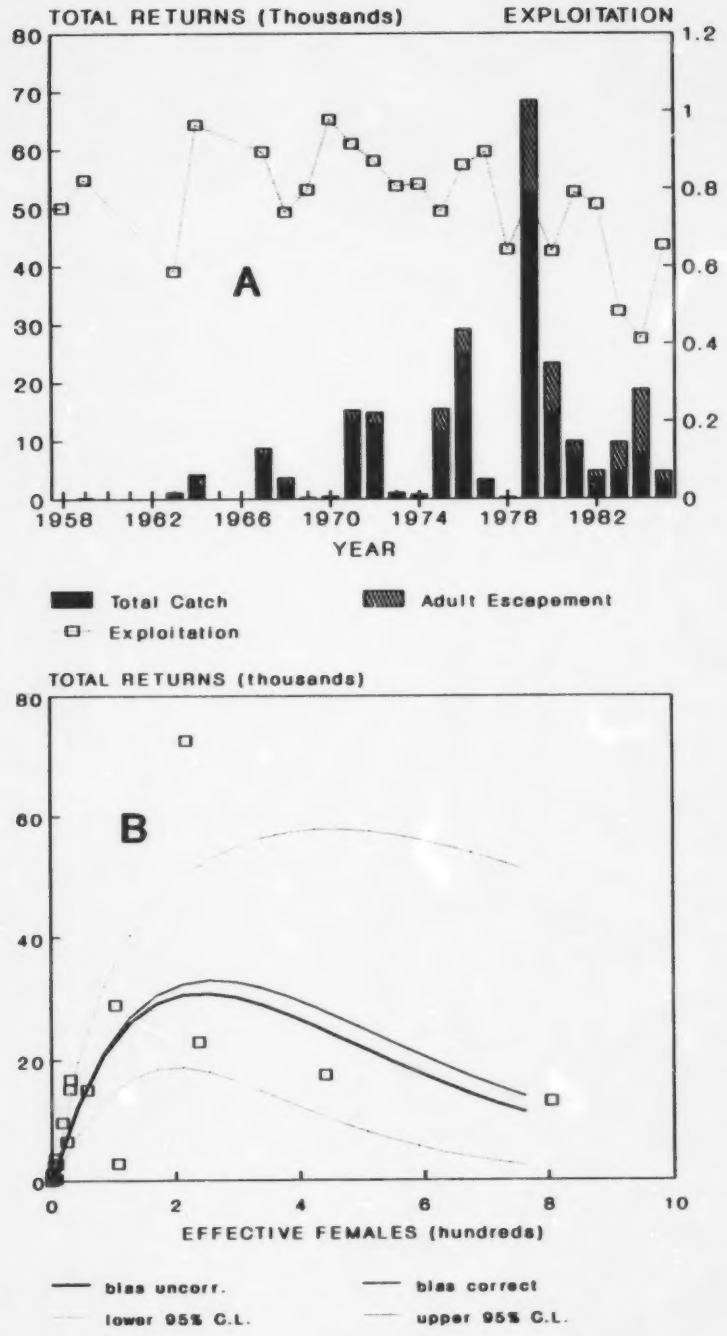

Fig. 16. A) Returns, catch, escapement and exploitation rate and B) the Ricker stock-recruitment relationship for Fennell Creek sockeye.

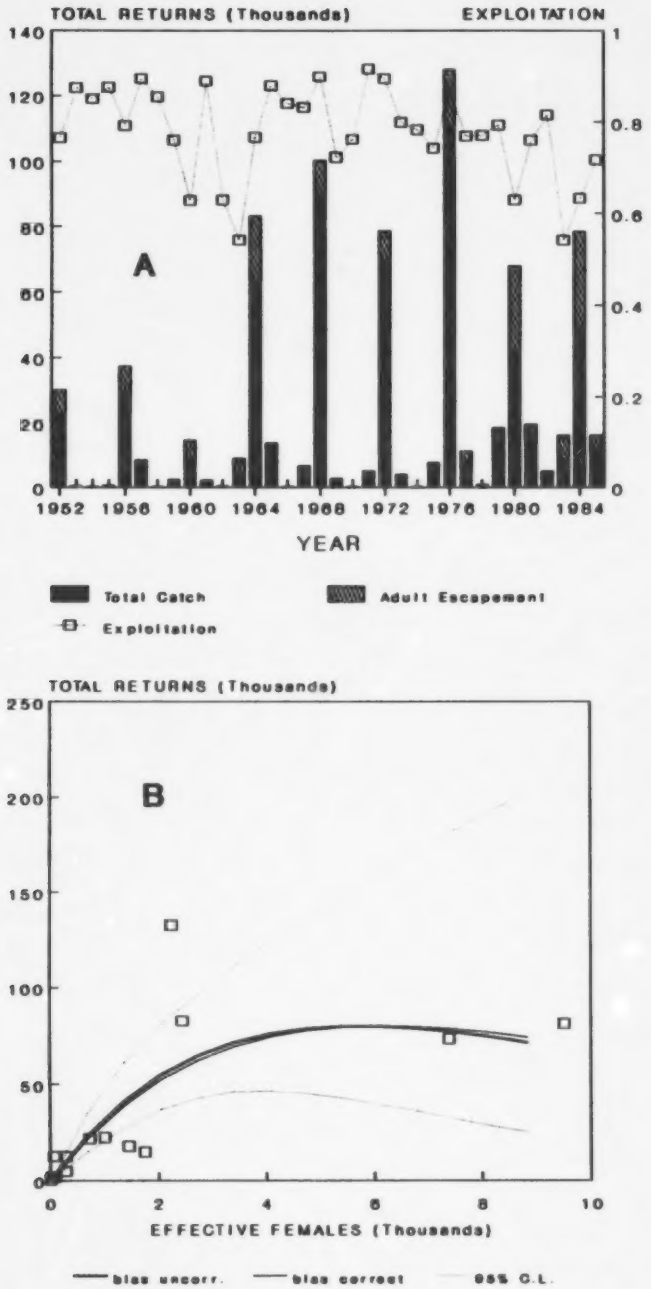

Fig. 17. A) Returns, catch, escapement and exploitation rate and B) the Ricker stock-recruitment relationship for Gates Creek sockeye.

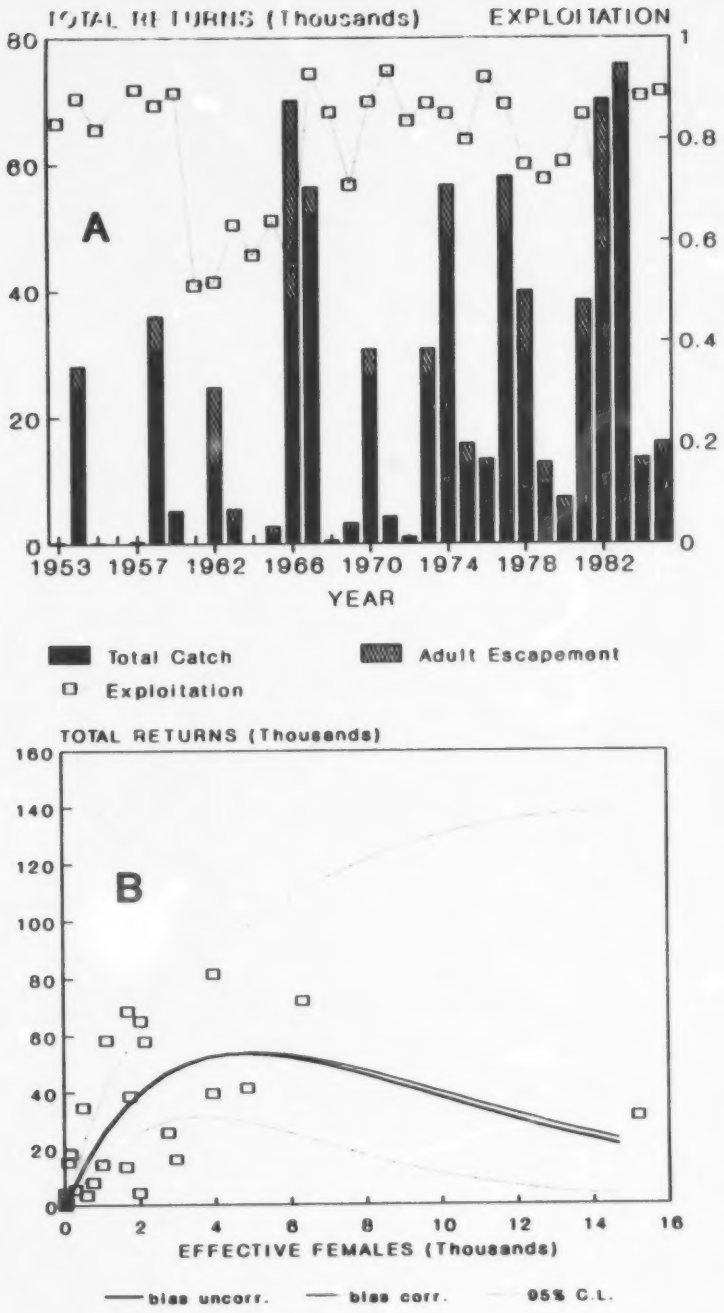

Fig. 18. A) Returns, catch, escapement and exploitation rate and B) the Ricker stock-recruitment relationship for Portage Creek sockeye.

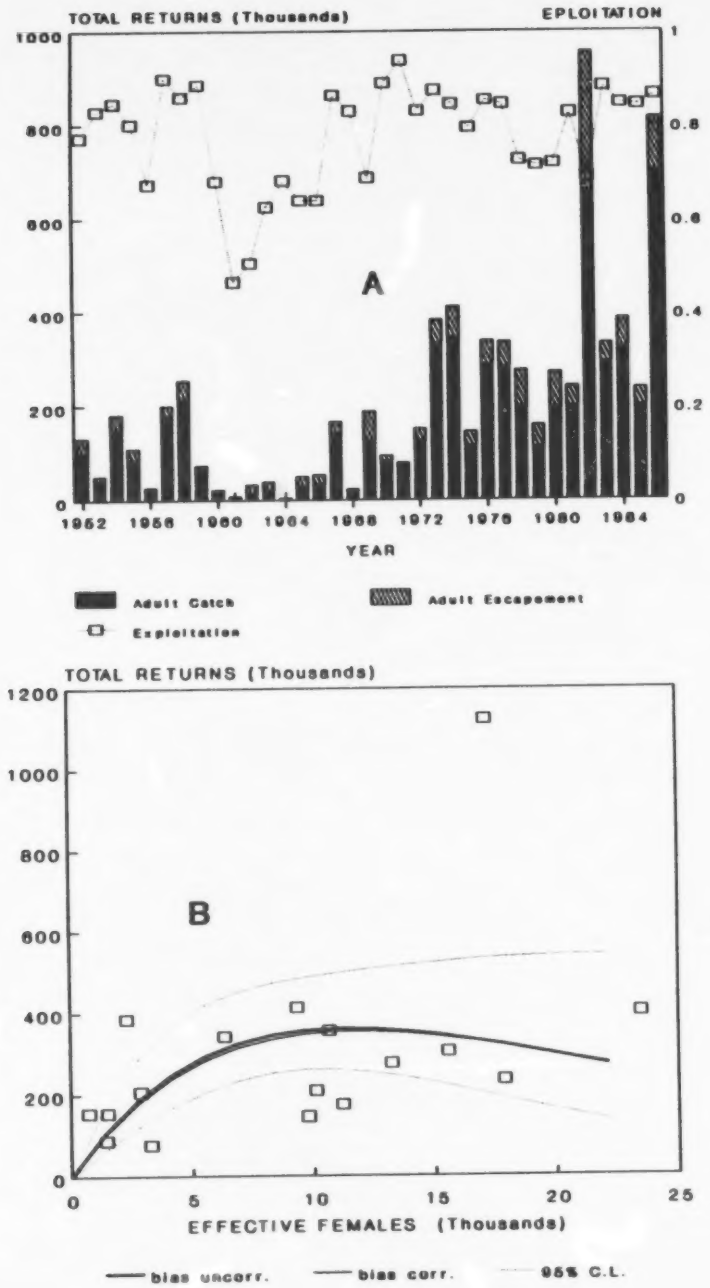

Fig. 19. A) Returns, catch, escapement and exploitation rate and B) the Ricker stock-recruitment relationship for Weaver Creek sockeye.

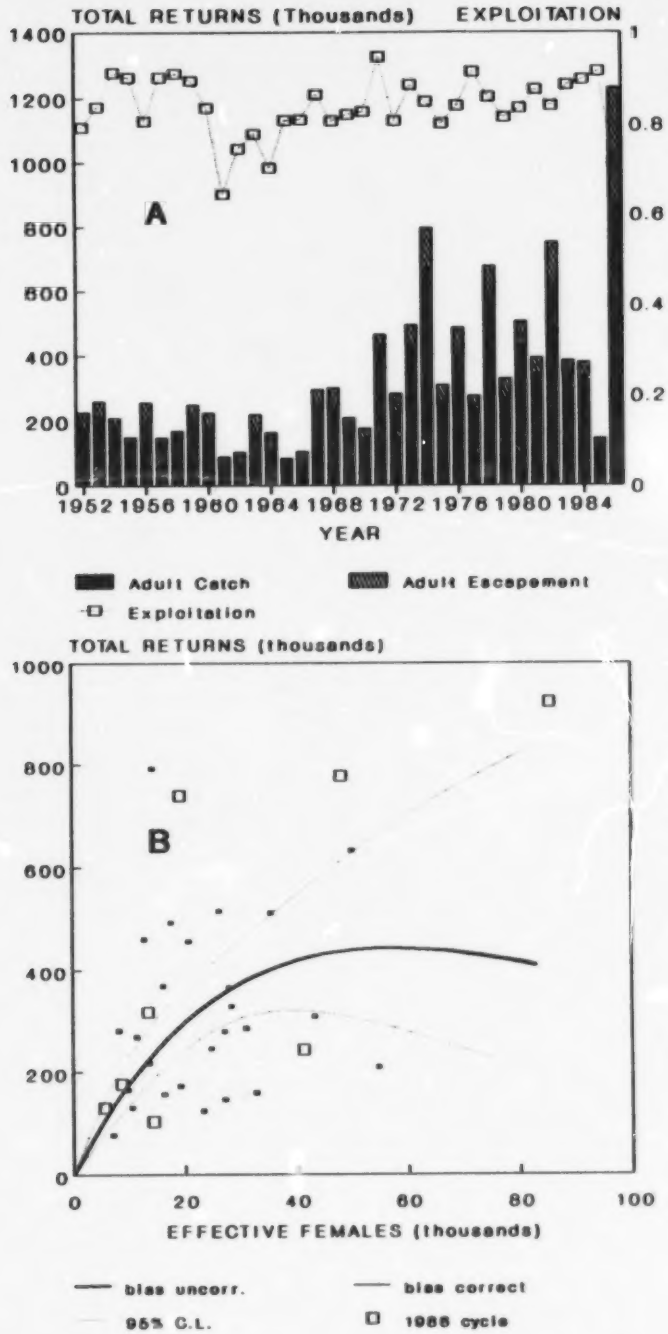

Fig. 20. A) Returns, catch, escapement and exploitation rate and B) the Ricker stock-recruitment relationship for Birkenhead River sockeye.

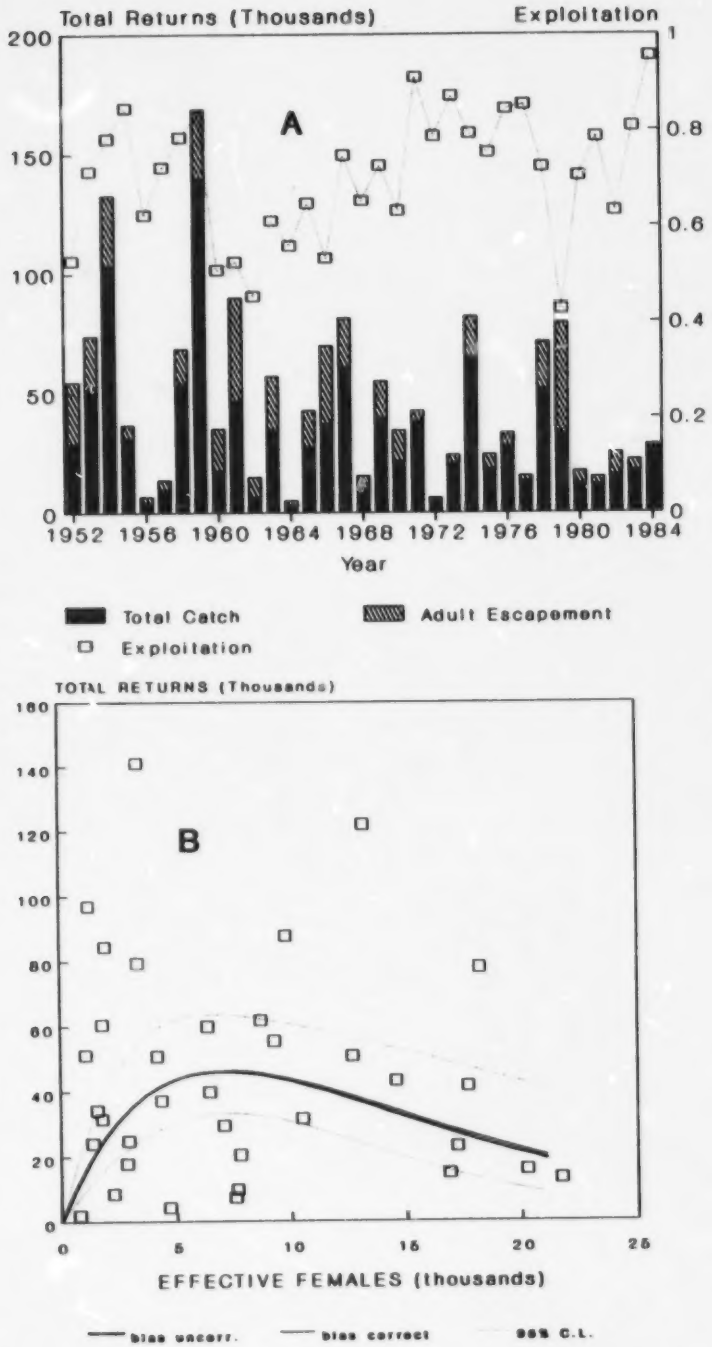

Fig. 21. A) Returns, catch, escapement and exploitation rate and B) the Ricker stock-recruitment relationship for Harrison River sockeye.

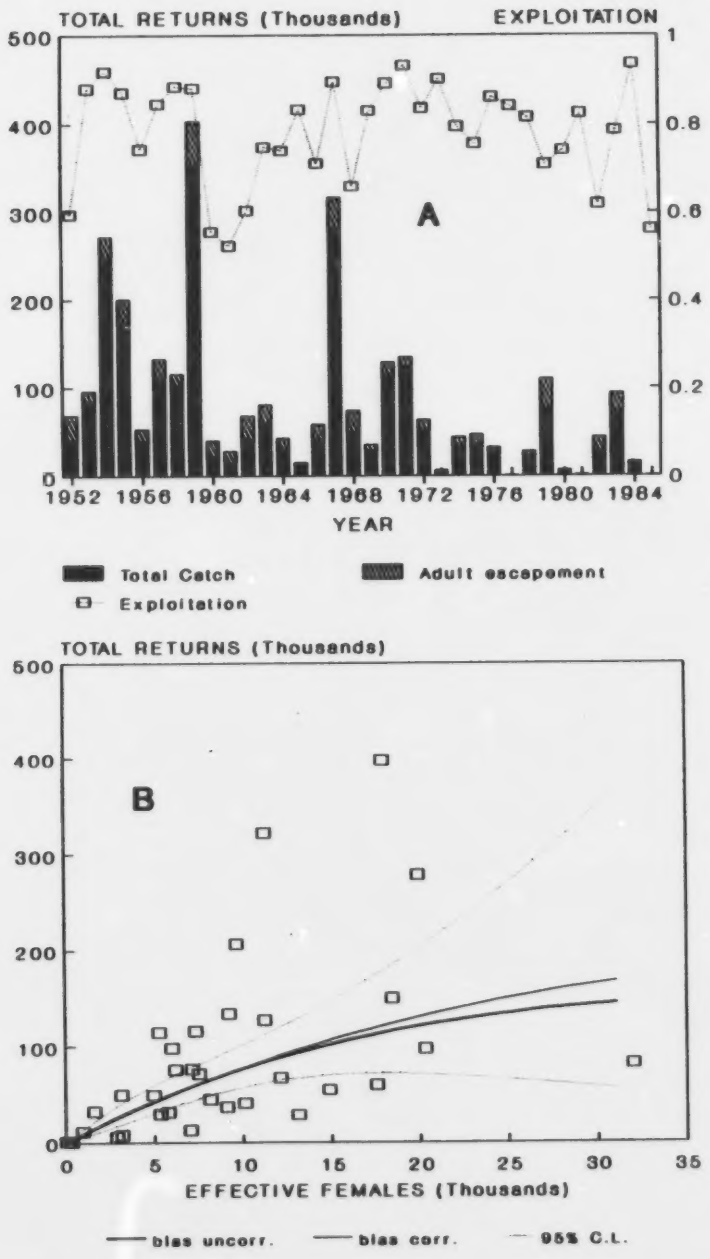

Fig. 22. A) Returns, catch, escapement and exploitation rate and B) the Ricker stock-recruitment relationship for Cultus Lake sockeye.

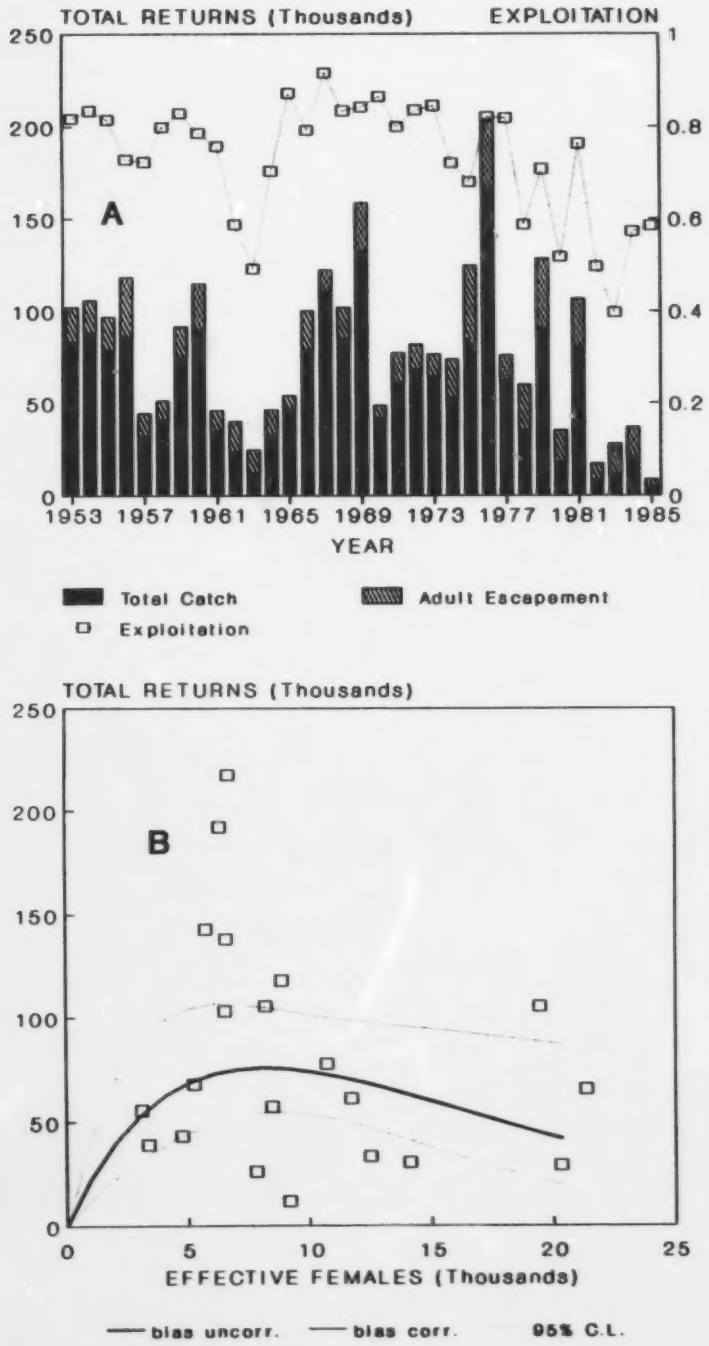

Fig. 23. A) Returns, catch, escapement and exploitation rate and B) the Ricker stock-recruitment relationship for the Upper Pitt River sockeye.

Appendix A. Fraser River sockeye escapement and return data.

Table 1. Total Fraser River sockeye escapement, return and returns per spawner data for all years and by cycle.

Table 2. Early Stuart sockeye escapement, return and returns per spawner data for all years and by cycle.

Table 3. Late Stuart sockeye escapement, return and returns per spawner data for all years and by cycle.

Table 4. Late Nadina River sockeye escapement, return and returns per spawner data for all years and by cycle.

Table 5. P. Stellako River sockeye escapement, return and returns per spawner data for all years and by cycle.

Table 6. Bowron River sockeye escapement, return and returns per spawner data for all years and by cycle.

Table 7. Horsefly River sockeye escapement, return and returns per spawner data for all years and by cycle.

Table 8. Mitchell River sockeye escapement, return and returns per spawner data for all years and by cycle.

Table 9. Chilko River sockeye escapement, return and returns per spawner data for all years and by cycle.

Table 10. Chilko Lake south end (early Chilko) sockeye escapement, return and returns per spawner data for all years and by cycle.

Table 11. Total Chilko Lake sockeye escapement, return and returns per spawner data for all years and by cycle.

Table 12. Seymour River sockeye escapement, return and returns per spawner data for all years and by cycle.

Table 13. Scotch Creek sockeye escapement, return and returns per spawner data for all years and by cycle.

Table 14. Lower Adams sockeye escapement, return and returns per spawner data for all years and by cycle.

Table 15. Lower Shuswap River sockeye escapement, return and returns per spawner data for all years and by cycle.

Table 16. Total Shuswap Lake sockeye escapement, return and returns per spawner data for all years and by cycle.

Table 17. Raft River sockeye escapement, return and returns per spawner data for all years and by cycle.

Table 18. Fennel Creek sockeye escapement, return and returns per spawner data for all years and by cycle.

Table 19. Weaver Creek sockeye escapement, return and returns per spawner data for all years and by cycle.

Table 20. Birkenhead River sockeye escapement, return and returns per spawner data for all years and by cycle.

Table 21. Harrison River sockeye escapement, return and returns per spawner data for all years and by cycle.

Table 22. Portage Creek sockeye escapement, return and returns per spawner data for all years and by cycle.

Table 23. Gates Creek sockeye escapement, return and returns per spawner data for all years and by cycle.

Table 24. Upper Pitt River sockeye escapement, return and returns per spawner data for all years and by cycle.

Table 25. Cultus Lake sockeye escapement, return and returns per spawner data for all years and by cycle.

APPENDIX A. TABLE 1.

FRASER RIVER (TOTAL) SOCKEYE

ALL YEARS

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948	966,557	3,278,908	3.39
1949	1,066,120	5,019,371	4.71
1950	1,737,559	12,829,594	7.38
1951	564,250	2,922,620	5.18
1952	795,605	2,694,958	3.40
1953	1,058,917	4,614,668	4.36
1954	2,415,020	19,598,497	8.12
1955	361,443	4,689,641	12.97
1956	858,398	3,475,179	4.05
1957	1,340,150	4,415,267	3.29
1958	3,822,300	3,696,304	0.97
1959	927,364	4,030,988	4.35
1960	620,915	1,713,845	2.76
1961	1,160,439	3,121,160	2.69
1962	1,575,446	5,380,055	3.41
1963	1,577,943	6,879,196	4.36
1964	388,300	3,206,742	8.26
1965	774,253	4,406,026	5.69
1966	1,797,994	6,387,909	3.55
1967	1,331,836	7,679,145	5.77
1968	592,773	3,644,628	6.15
1969	925,071	6,994,997	7.58
1970	1,860,400	8,494,129	4.57
1971	719,639	3,814,409	5.30
1972	760,641	4,323,183	5.68
1973	1,044,355	5,604,080	5.37
1974	1,656,552	9,952,207	6.01
1975	920,795	6,194,389	6.73
1976	781,040	3,263,859	4.15
1977	1,014,014	7,648,192	7.54
1978	2,484,805	14,420,431	5.80
1979	1,368,139	5,013,251	3.66
1980	829,754	5,294,354	6.38
1981	1,384,102	13,560,816	9.80
1982	4,007,720	15,040,100	3.75
1983	964,917		
1984	922,059		
1985	2,077,686		
AVG:	1,301,349	6,379,517	4.88 (GM)
MAX:	4,007,720	19,598,497	12.97
MIN:	361,443	1,713,845	0.97

1984 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948	966,557	3,278,908	3.39
1952	795,605	2,694,958	3.40
1956	858,398	3,475,179	4.05
1960	620,915	1,713,845	2.76
1964	388,300	3,206,742	8.26
1968	592,773	3,644,628	6.15
1972	760,641	4,323,183	5.68
1976	781,040	3,263,859	4.15
1980	829,754	5,294,354	6.38
1984	922,059		
AVG:	751,404	3,430,628	4.63 (GM)
MAX:	966,557	5,294,354	8.26
MIN:	388,300	1,713,845	2.76

1985 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1949	1,066,120	5,019,371	4.71
1953	1,058,917	4,614,668	4.36
1957	1,340,150	4,415,267	3.29
1961	1,160,439	3,121,160	2.69
1965	774,253	4,406,026	5.69
1969	925,071	6,994,997	7.58
1973	1,044,355	5,604,080	5.37
1977	1,014,014	7,648,192	7.54
1981	1,384,102	13,560,816	9.80
1985	2,077,686		
AVG:	1,184,311	6,153,842	5.27 (GM)
MAX:	2,077,686	13,560,816	9.80
MIN:	774,253	3,121,160	2.69

1986 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1950	1,737,559	12,829,594	7.38
1954	2,415,020	19,598,497	8.12
1958	3,822,300	3,696,304	0.97
1962	1,575,446	5,380,055	3.41
1966	1,797,994	6,387,909	3.55
1970	1,860,400	8,494,129	4.57
1974	1,656,552	9,952,207	6.01
1978	2,484,805	14,420,431	5.80
1982	4,007,720	15,040,100	3.75
AVG:	2,373,088	10,644,356	4.22 (GM)
MAX:	4,007,720	19,598,497	8.12
MIN:	1,575,446	3,696,304	0.97

1987 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1951	564,250	2,922,620	5.18
1955	361,443	4,689,641	12.97
1959	927,364	4,030,988	4.35
1963	1,577,943	6,879,196	4.36
1967	1,331,836	7,679,145	5.77
1971	719,639	3,814,409	5.30
1975	920,795	6,194,389	6.73
1979	1,368,139	5,013,251	3.66
1983	964,917		
AVG:	970,705	5,152,955	5.59 (GM)
MAX:	1,577,943	7,679,145	12.97
MIN:	361,443	2,922,620	3.66

Appendix A. Table 2.

EARLY STUART SOCKEYE

ALL YEARS

Brood Year	Adult Spawner	Total Return	Return Per Spawner
1948	19,979	198,153	9.92
1949	582,228	1,036,968	1.78
1950	59,104	241,666	4.09
1951	60,423	173,654	2.87
1952	30,212	88,600	2.93
1953	154,036	540,891	3.51
1954	35,050	155,823	4.45
1955	2,159	27,467	12.72
1956	25,020	110,394	4.41
1957	234,850	1,222,956	5.21
1958	38,807	103,107	2.66
1959	2,670	20,835	7.80
1960	14,447	74,149	5.13
1961	198,921	255,842	1.29
1962	26,716	75,785	2.84
1963	4,607	92,554	20.09
1964	2,390	42,887	17.94
1965	23,045	417,211	18.10
1966	10,880	84,786	7.85
1967	21,044	339,693	16.14
1968	1,522	10,423	6.85
1969	109,655	1,375,594	12.54
1970	32,578	182,136	5.59
1971	95,940	431,210	4.49
1972	4,657	32,252	6.92
1973	299,892	1,341,984	4.47
1974	39,518	140,516	3.56
1975	65,754	224,052	3.41
1976	11,761	31,854	2.71
1977	117,445	757,997	6.45
1978	50,004	56,170	1.12
1979	92,746	108,699	1.17
1980	16,959	64,115	3.79
1981	129,457	331,330	2.56
1982	4,557	25,800	5.66
1983	23,867		
1984	45,201		
1985	234,519		
AVG:	76,909	297,643	4.86 (GM)
MAX:	582,228	1,375,594	20.09
MIN:	1,522	10,423	1.12

1984 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948	19,979	198,153	9.92
1952	30,212	88,600	2.93
1956	25,020	110,394	4.41
1960	14,447	74,149	5.13
1964	2,390	42,887	17.94
1968	1,522	10,423	6.85
1972	4,657	32,252	6.92
1976	11,761	31,854	2.71
1980	16,959	64,115	3.79
1984	45,201		
AVG:	17,213	72,534	5.64 (GM)
MAX:	45,201	198,153	17.94
MIN:	1,522	10,423	2.71

1985 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1949	582,228	1,036,968	1.78
1953	154,036	540,891	3.51
1957	234,850	1,222,956	5.21
1961	198,921	255,842	1.29
1965	23,045	417,211	18.10
1969	109,655	1,375,594	12.54
1973	299,892	1,341,984	4.47
1977	117,445	757,997	6.45
1981	129,457	331,330	2.56
1985	234,519		
AVG:	208,405	808,973	4.46 (GM)
MAX:	582,228	1,375,594	18.10
MIN:	23,045	255,842	1.29

1986 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1950	59,104	241,666	4.09
1954	35,050	155,823	4.45
1958	38,807	103,107	2.66
1962	26,716	75,785	2.84
1966	10,880	84,786	7.85
1970	32,578	182,136	5.59
1974	39,518	140,516	3.56
1978	50,004	56,170	1.12
1982	4,557	25,800	5.66
AVG:	33,018	118,421	3.72 (GM)
MAX:	59,104	241,666	7.85
MIN:	4,557	25,800	1.12

1987 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1951	60,423	173,654	2.87
1955	2,159	27,467	12.72
1959	2,670	20,835	7.80
1963	4,607	92,554	20.09
1967	21,044	339,693	16.14
1971	95,940	431,210	4.49
1975	65,754	224,052	3.41
1979	92,746	108,699	1.17
1983	23,867		
AVG:	41,023	177,271	5.99 (GM)
MAX:	95,940	431,210	20.09
MIN:	2,159	20,835	1.17

Appendix A. Table 3.

LATE STUART SOCKEYE

ALL YEARS

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948		327	
1949	107,752	1,530,202	14.20
1950	5,863	39,681	6.79
1951	4,364	63,810	14.62
1952	35	3,973	113.51
1953	368,634	1,552,239	4.21
1954	5,470	137,965	25.22
1955	7,582	51,345	6.77
1956	913	46,102	50.50
1957	531,108	1,329,884	2.50
1958	23,619	54,677	2.31
1959	8,225	7,392	0.90
1960	2,396	9,617	4.01
1961	410,887	778,478	1.89
1962	18,643	45,069	2.42
1963	3,222	12,049	3.74
1964	1,816	3,101	1.71
1965	214,943	1,126,519	5.23
1966	9,027	74,079	8.21
1967	1,629	16,556	10.16
1968	389	31,299	80.46
1969	207,014	1,625,590	7.85
1970	14,978	70,838	4.73
1971	1,535	66,770	43.50
1972	7,341	17,266	2.35
1973	214,230	606,161	2.83
1974	14,190	43,407	3.06
1975	14,229	196,849	13.83
1976	2,898	3,339	1.15
1977	146,459	1,349,483	9.21
1978	12,738	62,421	4.90
1979	31,918	9,750	0.31
1980	946	9,811	10.37
1981	249,494	1,978,010	7.93
1982	16,758	54,300	3.24
1983	2,246		
1984	1,228		
1985	274,620		
AVG:	79,441	371,610	5.97 (GM)
MAX:	531,108	1,978,010	113.51
MIN:	35	327	0.31

1984 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948		327	
1952	35	3,973	113.51
1956	913	46,102	50.50
1960	2,396	9,617	4.01
1964	1,816	3,101	1.71
1968	389	31,299	80.46
1972	7,341	17,266	2.35
1976	2,898	3,339	1.15
1980	946	9,811	10.37
1984	1,228		
AVG:	1,996	13,871	9.85 (GM)
MAX:	7,341	46,102	113.51
MIN:	35	327	1.15

1985 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1949	107,752	1,530,202	14.20
1953	368,634	1,552,239	4.21
1957	531,108	1,329,884	2.50
1961	410,887	778,478	1.89
1965	214,943	1,126,519	5.23
1969	207,014	1,625,590	7.85
1973	214,230	606,161	2.83
1977	146,459	1,349,483	9.21
1981	249,494	1,978,010	7.93
1985	274,620		
AVG:	272,514	1,319,396	5.12 (GM)
MAX:	531,108	1,978,010	14.20
MIN:	107,752	606,161	1.89

1986 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1950	5,863	39,681	6.79
1954	5,470	137,965	25.22
1958	23,619	54,677	2.31
1962	18,643	45,069	2.42
1966	9,027	74,079	8.21
1970	14,978	70,838	4.73
1974	14,190	43,407	3.06
1978	12,738	62,421	4.90
1982	16,758	54,300	3.24
AVG:	13,474	64,715	4.96 (GM)
MAX:	23,619	137,965	25.22
MIN:	5,470	39,681	2.31

1987 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1951	4,364	63,810	14.62
1955	7,582	51,345	6.77
1959	8,225	7,392	0.90
1963	3,222	12,049	3.74
1967	1,629	16,556	10.16
1971	1,535	66,770	43.50
1975	14,229	196,849	13.83
1979	31,918	9,750	0.31
1983	2,246		
AVG:	8,328	53,065	5.30 (GM)
MAX:	31,918	196,849	43.50
MIN:	1,535	7,392	0.31

Appendix A. Table 4.

LATE MEDINA SOCKEYE

ALL YEARS

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948		43	
1949		105,947	
1950	774	5,097	6.59
1951	175	981	5.61
1952	9	91	10.11
1953	13,617	162,560	11.94
1954	770	4,725	6.14
1955	106	3,953	37.29
1956	18	4,108	228.22
1957	27,549	116,806	4.24
1958	635	5,083	8.00
1959	1,013	17,000	16.78
1960	29	1,178	40.62
1961	17,542	94,420	5.38
1962	1,683	12,045	7.16
1963	7,304	59,653	8.17
1964	209	7,735	37.01
1965	11,295	95,017	8.41
1966	1,724	34,010	19.73
1967	7,790	153,066	19.65
1968	1,249	43,963	35.20
1969	27,895	106,259	3.81
1970	3,929	29,886	7.61
1971	14,481	75,454	5.21
1972	2,554	10,728	4.20
1973	16,720	79,728	4.77
1974	3,730	12,482	3.35
1975	15,309	307,348	20.08
1976	1,625	7,257	4.47
1977	16,858	129,205	7.66
1978	2,584	17,832	6.90
1979	55,681	92,270	1.66
1980	3,017	18,774	6.22
1981	18,912	73,315	3.88
1982	2,349		
1983	26,876		
1984	7,070		
1985	13,807		
AVG:	9,080	55,530	9.40 (GM)
MAX:	55,681	307,348	228.22
MIN:	9	43	1.66

1984 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948		43	
1952	9	91	10.11
1956	18	4,108	228.22
1960	29	1,178	40.62
1964	209	7,735	37.01
1968	1,249	43,963	35.20
1972	2,554	10,728	4.20
1976	1,625	7,257	4.47
1980	3,017	18,774	6.22
1984	7,070		
AVG:	1,753	10,431	18.59 (GM)
MAX:	7,070	43,963	228.22
MIN:	9	43	4.20

1985 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1949		105,947	
1953	13,617	162,560	11.94
1957	27,549	116,806	4.24
1961	17,542	94,420	5.38
1965	11,295	95,017	8.41
1969	27,895	106,259	3.81
1973	16,720	79,728	4.77
1977	16,858	129,205	7.66
1981	18,912	73,315	3.88
1985	13,807		
AVG:	18,244	107,029	5.77 (GM)
MAX:	27,895	162,560	11.94
MIN:	11,295	73,315	3.81

1986 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1950	774	5,097	6.59
1954	770	4,725	6.14
1958	635	5,083	8.00
1962	1,683	12,045	7.16
1966	1,724	34,010	19.73
1970	3,929	29,886	7.61
	3,730	12,482	3.35
1978	2,584	17,832	6.90
1982	2,349		
AVG:	2,020	15,145	7.30 (GM)
MAX:	3,929	34,010	19.73
MIN:	635	4,725	3.35

1987 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1951	175	981	5.61
1955	106	3,953	37.29
1959	1,013	17,000	16.78
1963	7,304	59,653	8.17
1967	7,790	153,066	19.65
1971	14,481	75,454	5.21
1975	15,309	307,348	20.08
1979	55,681	92,270	1.66
1983	26,876		
AVG:	14,304	88,716	9.97 (GM)
MAX:	55,681	307,348	37.29
MIN:	106	981	1.66

Note - Includes Early Medina, Nithi & Erchiko.

Appendix A. Table 5. STELLAKO RIVER SOCKEYE

ALL YEARS

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948	15,763	207,177	13.14
1949	104,720	179,876	1.72
1950	145,021	959,117	6.48
1951	96,076	455,367	4.74
1952	40,384	110,701	2.74
1953	42,134	174,245	4.14
1954	141,859	1,211,299	8.54
1955	51,739	629,796	12.17
1956	38,438	246,735	6.42
1957	38,522	151,863	3.94
1958	112,251	340,460	3.03
1959	79,305	541,420	6.83
1960	38,880	164,514	4.23
1961	46,863	147,402	3.15
1962	124,485	589,505	4.74
1963	138,794	727,926	5.24
1964	30,890	177,837	5.76
1965	39,385	243,651	6.19
1966	101,529	359,906	3.54
1967	91,480	550,524	6.02
1968	30,368	129,822	4.27
1969	49,211	253,245	5.15
1970	45,797	234,108	5.11
1971	39,691	509,267	12.83
1972	36,700	758,244	20.66
1973	30,404	77,458	2.55
1974	41,275	262,761	6.37
1975	175,941	1,750,826	9.95
1976	150,734	244,377	1.62
1977	23,047	264,679	11.48
1978	58,898	416,677	7.07
1979	290,042	577,863	1.99
1980	72,050	424,166	5.89
1981	21,826	234,242	10.73
1982	69,420	377,500	5.44
1983	121,692		
1984	60,957		
1985	42,099		
AVG:	75,754	418,986	5.41 (GM)
MAX:	290,042	1,750,826	20.66
MIN:	15,763	77,458	1.62

1984 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948	15,763	207,177	13.14
1952	40,384	110,701	2.74
1956	38,438	246,735	6.42
1960	38,880	164,514	4.23
1964	30,890	177,837	5.76
1968	30,368	129,822	4.27
1972	36,700	758,244	20.66
1976	150,734	244,377	1.62
1980	72,050	424,166	5.89
1984	60,957		
AVG:	51,516	273,730	5.52 (GM)
MAX:	150,734	758,244	20.66
MIN:	15,763	110,701	1.62

1985 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1949	104,720	179,876	1.72
1953	42,134	174,245	4.14
1957	38,522	151,863	3.94
1961	46,863	147,402	3.15
1965	39,385	243,651	6.19
1969	49,211	253,245	5.15
1973	30,404	77,458	2.55
1977	23,047	264,679	11.48
1981	21,826	234,242	10.73
1985	42,099		
AVG:	43,821	191,849	4.58 (GM)
MAX:	104,720	264,679	11.48
MIN:	21,826	77,458	1.72

1986 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1950	145,021	959,117	6.48
1954	141,859	1,211,299	8.54
1958	112,251	340,460	3.03
1962	124,485	589,505	4.74
1966	101,529	359,906	3.54
1970	45,797	234,108	5.11
1974	41,275	262,761	6.37
1978	58,898	416,677	7.07
1982	69,420	377,500	5.44
AVG:	95,393	525,704	5.34 (GM)
MAX:	145,021	1,211,299	8.54
MIN:	41,275	234,108	3.03

1987 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1951	96,076	455,367	4.74
1955	51,739	629,796	12.17
1959	79,305	541,420	6.83
1963	138,794	727,926	5.24
1967	91,480	550,524	6.02
1971	39,691	509,267	12.83
1975	175,941	1,750,826	9.95
1979	290,042	577,863	1.99
1983	121,692		
AVG:	120,529	717,871	6.49 (GM)
MAX:	290,042	1,750,826	12.83
MIN:	39,691	455,367	1.99

Appendix A. Table 6.

BOURON RIVER SOCKEYE

ALL YEARS

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948	25,205	80,266	3.18
1949	22,283	62,791	2.82
1950	16,146	75,548	4.68
1951	21,731	103,821	4.78
1952	18,645	43,304	2.32
1953	13,277	75,579	5.69
1954	10,515	66,916	6.36
1955	9,350	96,955	10.37
1956	6,964	38,484	5.53
1957	12,011	41,966	3.49
1958	14,863	18,155	1.22
1959	29,247	61,865	2.12
1960	7,620	17,733	2.33
1961	7,449	28,148	3.78
1962	6,286	21,327	3.39
1963	25,141	214,316	8.52
1964	1,500	27,507	18.34
1965	2,659	17,849	6.71
1966	2,470	22,249	9.01
1967	31,695	206,494	6.52
1968	3,611	44,642	12.36
1969	3,872	17,211	4.44
1970	1,305	16,197	12.41
1971	25,497	126,507	4.88
1972	4,138	20,361	4.92
1973	4,558	8,564	1.88
1974	1,850	12,396	6.70
1975	29,700	170,357	5.74
1976	2,250	7,112	3.16
1977	2,500	8,609	3.44
1978	3,141	20,314	6.47
1979	35,000	21,542	0.62
1980	2,894	22,407	7.74
1981	1,170	14,726	12.58
1982	1,647		
1983	6,451		
1984	10,461		
1985	6,395		
AVG:	11,355	53,830	4.72 (GM)
MAX:	35,000	214,316	18.34
MIN:	1,170	7,112	0.62

1984 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948	25,205	80,266	3.18
1952	18,645	43,304	2.32
1956	6,964	38,484	5.53
1960	7,620	17,733	2.33
1964	1,500	27,507	18.34
1968	3,611	44,642	12.36
1972	4,138	20,361	4.92
1976	2,250	7,112	3.16
1980	2,894	22,407	7.74
1984	10,461		
AVG:	8,329	33,535	5.16 (GM)
MAX:	25,205	80,266	18.34
MIN:	1,500	7,112	2.32

1985 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1949	22,283	62,791	2.82
1953	13,277	75,579	5.69
1957	12,011	41,966	3.49
1961	7,449	28,148	3.78
1965	2,659	17,849	6.71
1969	3,872	17,211	4.44
1973	4,558	8,564	1.88
1977	2,500	8,609	3.44
1981	1,170	14,726	12.58
1985	6,395		
AVG:	7,617	30,605	4.31 (GM)
MAX:	22,283	75,579	12.58
MIN:	1,170	8,564	1.88

1986 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1950	16,146	75,548	4.68
1954	10,515	66,916	6.36
1958	14,863	18,155	1.22
1962	6,286	21,327	3.39
1966	2,470	22,249	9.01
1970	1,305	16,197	12.41
1974	1,850	12,396	6.70
1978	3,141	20,314	6.47
1982	1,647		
AVG:	6,467	31,638	5.27 (GM)
MAX:	16,146	75,548	12.41
MIN:	1,305	12,396	1.22

1987 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1951	21,731	103,821	4.78
1955	9,350	96,955	10.37
1959	29,247	61,865	2.12
1963	25,141	214,316	8.52
1967	31,695	206,494	6.52
1971	25,497	126,507	4.88
1975	29,700	170,357	5.74
1979	35,000	21,542	0.62
1983	6,451		
AVG:	23,757	126,982	4.22 (GM)
MAX:	35,000	214,316	10.37
MIN:	6,451	21,542	0.62

Note - Includes Indianpoint Creek.

Appendix A. Table 7. HORSEFLY RIVER SOCKEYE

ALL YEARS

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948	100	1,132	11.32
1949	30,000	476,070	15.87
1950	398	1,927	4.84
1951	49	413	8.43
1952	184	562	3.05
1953	108,573	602,995	5.55
1954	281	10,312	36.70
1955	63	180	2.86
1956	81	2,553	31.52
1957	220,990	976,515	4.42
1958	1,798	3,396	1.89
1959	65	165	2.54
1960	292	1,475	5.05
1961	295,964	1,223,026	4.13
1962	1,073	6,700	6.24
1963	83	956	11.52
1964	254	2,797	11.01
1965	359,371	1,614,217	4.49
1966	1,607	7,342	4.57
1967	119	1,761	14.80
1968	695	484	0.70
1969	270,022	1,496,320	5.54
1970	1,345	20,339	15.12
1971	171	747	4.37
1972	108	1,392	12.89
1973	253,388	1,983,829	7.83
1974	4,459	18,336	4.11
1975	193	1,713	8.88
1976	298	1,233	4.14
1977	473,803	3,547,060	7.49
1978	7,377	172,439	23.38
1979	511	4,828	9.45
1980	274	886	3.23
1981	682,515	8,125,619	11.91
1982	36,012	514,400	14.28
1983	2,036		
1984	895		
1985	1,113,172		
AVG:	101,806	594,975	6.82 (GM)
MAX:	1,113,172	8,125,619	36.70
MIN:	49	165	0.70

1984 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948	100	1,132	11.32
1952	184	562	3.05
1956	81	2,553	31.52
1960	292	1,475	5.05
1964	254	2,797	11.01
1968	695	484	0.70
1972	108	1,392	12.89
1976	298	1,233	4.14
1980	274	886	3.23
1984	895		
AVG:	318	1,390	5.79 (GM)
MAX:	895	2,797	31.52
MIN:	81	484	0.70

1985 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1949	30,000	476,070	15.87
1953	108,573	602,995	5.55
1957	220,990	976,515	4.42
1961	295,964	1,223,026	4.13
1965	359,371	1,614,217	4.49
1969	270,022	1,496,320	5.54
1973	253,388	1,983,829	7.83
1977	473,803	3,547,060	7.49
1981	682,515	8,125,619	11.91
1985	1,113,172		
AVG:	380,780	2,227,294	6.72 (GM)
MAX:	1,113,172	8,125,619	15.87
MIN:	30,000	476,070	4.13

1986 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1950	398	1,927	4.84
1954	281	10,312	36.70
1958	1,798	3,396	1.89
1962	1,073	6,700	6.24
1966	1,607	7,342	4.57
1970	1,345	20,339	15.12
1974	4,459	18,336	4.11
1978	7,377	172,439	23.38
1982	36,012	514,400	14.28
AVG:	6,039	83,910	8.36 (GM)
MAX:	36,012	514,400	36.70
MIN:	281	1,927	1.89

1987 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1951	49	413	8.43
1955	63	180	2.86
1959	65	165	2.54
1963	83	956	11.52
1967	119	1,761	14.80
1971	171	747	4.37
1975	193	1,713	8.88
1979	511	4,828	9.45
1983	2,036		
AVG:	366	1,345	6.65 (GM)
MAX:	2,036	4,828	14.80
MIN:	49	165	2.54

Appendix A. Table 8.

MITCHELL RIVER SOCKEYE

ALL YEARS

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948			
1949	664	9,794	14.75
1950		121	
1951			
1952			
1953	2,344	7,252	3.09
1954	18	380	21.11
1955			
1956			
1957	2,677	21,598	8.07
1958	65	16	0.25
1959			
1960			
1961	6,601	17,864	2.71
1962	5	587	117.40
1963			
1964			
1965	5,335	52,955	9.93
1966	142	120	0.85
1967			
1968	4	13	3.25
1969	8,959	144,443	16.16
1970	23		
1971			
1972	3		
1973	24,673	177,596	7.20
1974		2,886	
1975			
1976	7		
1977	42,396	320,878	7.57
1978	1,237	513	0.41
1979		117	
1980		9	
1981	66,106	1,448,788	21.92
1982	3,829		
1983	119		
1984	20		
1985	204,579		
AVG:	16,808	116,102	5.51 (GM)
MAX:	204,579	1,448,788	117.40
MIN:	3	9	0.25

1984 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948			
1952			
1956			
1960			
1964			
1968	4	13	3.25
1972	3		
1976	7		
1980		9	
1984	20		
AVG:	9	11	3.25 (GM)
MAX:	20	13	3.25
MIN:	3	9	3.25

1985 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1949	664	9,794	14.75
1953	2,344	7,252	3.09
1957	2,677	21,598	8.07
1961	6,601	17,864	2.71
1965	5,335	52,955	9.93
1969	8,959	144,443	16.16
1973	24,673	177,596	7.20
1977	42,396	320,878	7.57
1981	66,106	1,448,788	21.92
1985	204,579		
AVG:	36,431	244,574	8.32 (GM)
MAX:	204,579	1,448,788	21.92
MIN:	664	7,252	2.71

1986 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1950		121	
1954	18	380	21.11
1958	65	16	0.25
1962	5	587	117.40
1966	142	120	0.85
1970	23		
1974		2,886	
1978	1,237	513	0.41
1982	3,829		
AVG:	760	660	2.92 (GM)
MAX:	3,829	2,886	117.40
MIN:	5	16	0.25

1987 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1951			
1955			
1959			
1963			
1967			
1971			
1975			
1979		117	
1983	119		
AVG:	119	117	(GM)
MAX:	119	117	ESR
MIN:	119	117	ESR

Appendix A. Table 9.

CHILKO RIVER SOCKEYE

ALL YEARS

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948	670,622	1,947,973	2.90
1949	58,247	623,138	10.70
1950	17,308	205,875	11.89
1951	100,116	752,327	7.51
1952	485,585	1,858,476	3.83
1953	200,691	619,456	3.09
1954	34,296	712,749	20.78
1955	121,167	1,513,275	12.49
1956	646,906	2,435,670	3.77
1957	138,464	138,228	1.00
1958	120,104	433,371	3.61
1959	463,060	2,212,583	4.78
1960	426,546	1,053,335	2.47
1961	39,101	69,453	1.78
1962	77,713	985,562	12.68
1963	998,231	1,206,303	1.21
1964	238,272	2,040,082	8.56
1965	35,335	158,944	4.50
1966	209,619	889,200	4.24
1967	174,715	1,999,484	11.44
1968	413,862	2,461,877	5.95
1969	70,902	402,283	5.67
1970	135,388	688,611	5.09
1971	157,193	602,388	3.83
1972	562,650	1,938,682	3.45
1973	55,675	213,743	3.84
1974	109,563	600,641	5.48
1975	199,739	1,482,366	7.42
1976	361,752	1,616,968	4.47
1977	49,539	192,299	3.88
1978	143,402	1,178,463	8.22
1979	234,924	1,521,877	6.48
1980	467,812	4,283,976	9.16
1981	34,360	180,405	5.25
1982	239,903	1,671,700	6.97
1983	329,220		
1984	452,618		
1985	71,435		
AVG:	265,948	1,168,336	5.14 (GM)
MAX:	998,231	4,283,976	20.78
MIN:	17,308	69,453	1.00

1984 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948	670,622	1,947,973	2.90
1952	485,585	1,858,476	3.83
1956	646,906	2,435,670	3.77
1960	426,546	1,053,335	2.47
1964	238,272	2,040,082	8.56
1968	413,862	2,461,877	5.95
1972	562,650	1,938,682	3.45
1976	361,752	1,616,968	4.47
1980	467,812	4,283,976	9.16
1984	452,618		
AVG:	472,663	2,181,893	4.49 (GM)
MAX:	670,622	4,283,976	9.16
MIN:	238,272	1,053,335	2.47

1985 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1949	58,247	623,138	10.70
1953	200,691	619,456	3.09
1957	138,464	138,228	1.00
1961	39,101	69,453	1.78
1965	35,335	158,944	4.50
1969	70,902	402,283	5.67
1973	55,675	213,743	3.84
1977	49,539	192,299	3.88
1981	34,360	180,405	5.25
1985	71,435		
AVG:	75,375	288,661	3.66 (GM)
MAX:	200,691	623,138	10.70
MIN:	34,360	69,453	1.00

1986 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1950	17,308	205,875	11.89
1954	34,296	712,749	20.78
1958	120,104	433,371	3.61
1962	77,713	985,562	12.68
1966	209,619	889,200	4.24
1970	135,388	688,611	5.09
1974	109,563	600,641	5.48
1978	143,402	1,178,463	8.22
1982	239,903	1,671,700	6.97
AVG:	120,811	818,464	7.52 (GM)
MAX:	239,903	1,671,700	20.78
MIN:	17,308	205,875	3.61

1987 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1951	100,116	752,327	7.51
1955	121,167	1,513,275	12.49
1959	463,060	2,212,583	4.78
1963	998,231	1,206,303	1.21
1967	174,715	1,999,484	11.44
1971	157,193	602,388	3.83
1975	199,739	1,482,366	7.42
1979	234,924	1,521,877	6.48
1983	329,220		
AVG:	308,707	1,411,325	5.72 (GM)
MAX:	998,231	2,212,583	12.49
MIN:	100,116	602,388	1.21

Appendix A. Table 10. CHILKO SOUTH END LAKE SOCKEYE

ALL YEARS

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948			
1949			
1950			
1951			
1952			
1953			
1954			
1955			
1956			
1957			
1958			
1959			
1960			
1961			
1962			
1963			
1964			
1965			
1966			
1967			
1968		14,192	
1969			
1970		5,865	
1971	11,203	250,454	22.36
1972	1,883	95,316	50.62
1973		6,660	
1974	463	19,947	43.08
1975	44,892	158,274	3.53
1976	22,638	80,726	3.57
1977	1,791	1,769	0.99
1978	3,440	48,770	14.18
1979	23,467	137,398	5.85
1980	29,947	409,240	13.67
1981	180	4,848	26.93
1982	9,675		
1983	53,613		
1984	127,560		
1985	540		
AVG:	23,664	94,880	10.63 (GM)
MAX:	127,560	409,240	50.62
MIN:	180	1,769	0.99

1984 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948			
1952			
1956			
1960			
1964			
1968		14,192	
1972	1,883	95,316	50.62
1976	22,638	80,726	3.57
1980	29,947	409,240	13.67
1984	127,560		
AVG:	45,507	149,869	13.51 (GM)
MAX:	127,560	409,240	50.62
MIN:	1,883	14,192	3.57

1985 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1949			
1953			
1957			
1961			
1965			
1969			
1973		6,660	
1977	1,791	1,769	0.99
1981	180	4,848	26.93
1985	540		
AVG:	857	4,426	5.16 (GM)
MAX:	1,791	6,660	26.93
MIN:	180	1,769	0.99

1986 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1950			
1954			
1958			
1962			
1966			
1970		5,865	
1974	463	19,947	43.08
1978	3,440	48,770	14.18
1982	9,675		
AVG:	4,526	24,854	24.71 (GM)
MAX:	9,675	48,770	43.08
MIN:	463	5,865	14.18

1987 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1951			
1955			
1959			
1963			
1967			
1971	11,203	250,454	22.36
1975	44,892	158,274	3.53
1979	23,467	137,398	5.85
1983	53,613		
AVG:	33,294	182,042	7.73 (GM)
MAX:	53,613	250,454	22.36
MIN:	11,203	137,398	3.53

Appendix A. Table 11.

CHILKO LAKE TOTAL SOCKEYE

ALL YEARS

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948	670,622	1,947,973	2.90
1949	58,247	623,138	10.70
1950	17,308	205,875	11.89
1951	100,116	752,327	7.51
1952	485,585	1,858,476	3.83
1953	200,691	619,456	3.09
1954	34,296	712,749	20.78
1955	121,167	1,513,275	12.49
1956	646,906	2,435,670	3.77
1957	138,464	138,228	1.00
1958	120,104	433,371	3.61
1959	463,060	2,212,583	4.78
1960	426,546	1,053,335	2.47
1961	39,101	69,453	1.78
1962	77,713	985,562	12.68
1963	998,231	1,206,303	1.21
1964	238,272	2,040,082	8.56
1965	35,335	158,944	4.50
1966	209,619	889,200	4.24
1967	174,715	1,999,484	11.44
1968	413,862	2,476,069	5.98
1969	70,902	402,283	5.67
1970	135,388	694,456	5.13
1971	168,396	852,842	5.06
1972	564,533	2,033,998	3.60
1973	55,675	220,403	3.96
1974	110,026	620,588	5.64
1975	244,631	1,640,640	6.71
1976	384,390	1,697,694	4.42
1977	51,330	194,068	3.78
1978	146,842	1,227,233	8.36
1979	258,391	1,659,275	6.42
1980	497,759	4,693,216	9.43
1981	34,540	185,253	5.36
1982	249,578		
1983	382,833		
1984	580,178		
1985	71,975		
AVG:	254,667	1,189,809	5.14 (GM)
MAX:	998,231	4,693,216	20.78
MIN:	17,308	69,453	1.00

1984 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948	670,622	1,947,973	2.90
1952	485,585	1,858,476	3.83
1956	646,906	2,435,670	3.77
1960	426,546	1,053,335	2.47
1964	238,272	2,040,082	8.56
1968	413,862	2,476,069	5.98
1972	564,533	2,033,998	3.60
1976	384,390	1,697,694	4.42
1980	497,759	4,693,216	9.43
1984	580,178		
AVG:	490,865	2,248,501	4.52 (GM)
MAX:	670,622	4,693,216	9.43
MIN:	238,272	1,053,335	2.47

1985 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1949	58,247	623,138	10.70
1953	200,691	619,456	3.09
1957	138,464	138,228	1.00
1961	39,101	69,453	1.78
1965	35,335	158,944	4.50
1969	70,902	402,283	5.67
1973	55,675	220,403	3.96
1977	51,330	194,068	3.78
1981	34,540	185,253	5.36
1985	71,975		
AVG:	75,626	290,136	3.67 (GM)
MAX:	200,691	623,138	10.70
MIN:	34,540	69,453	1.00

1986 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1950	17,308	205,875	11.89
1954	34,296	712,749	20.78
1958	120,104	433,371	3.61
1962	77,713	985,562	12.68
1966	209,619	889,200	4.24
1970	135,388	694,456	5.13
1974	110,026	620,588	5.64
1978	146,842	1,227,233	8.36
1982	249,578		
AVG:	122,319	721,129	7.64 (GM)
MAX:	249,578	1,227,233	20.78
MIN:	17,308	205,875	3.61

1987 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1951	100,116	752,327	7.51
1955	121,167	1,513,275	12.49
1959	463,060	2,212,583	4.78
1963	998,231	1,206,303	1.21
1967	174,715	1,999,484	11.44
1971	168,396	852,842	5.06
1975	244,631	1,640,640	6.71
1979	258,391	1,659,275	6.42
1983	382,833		
AVG:	323,506	1,479,591	5.84 (GM)
MAX:	998,231	2,212,583	12.49
MIN:	100,116	752,327	1.21

Includes Chilko River, North End Lake and South End (Early Chilko).

Appendix A. Table 12.

SEYMOUR RIVER SOCKEYE

ALL YEARS

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948	3,889	29,658	7.63
1949	10,772	34,705	3.22
1950	11,049	162,026	14.66
1951	24,320	68,943	2.83
1952	5,963	11,249	1.89
1953	5,692	45,268	7.95
1954	24,774	461,522	18.63
1955	8,971	310,002	34.56
1956	2,490	12,763	5.13
1957	10,870	24,583	2.26
1958	78,371	195,518	2.49
1959	52,310	175,980	3.36
1960	2,902	8,837	3.05
1961	3,622	32,923	9.09
1962	57,836	176,546	3.05
1963	71,654	114,086	1.59
1964	2,745	18,498	6.74
1965	6,089	34,890	5.73
1966	28,698	141,828	4.94
1967	13,361	220,851	16.53
1968	3,838	22,108	5.76
1969	7,176	14,875	2.07
1970	11,971	226,369	18.91
1971	19,028	135,310	7.11
1972	2,802	58,719	20.96
1973	2,704	25,180	9.31
1974	44,588	181,851	4.08
1975	36,828	217,930	5.92
1976	8,306	22,250	2.68
1977	5,709	57,980	10.15
1978	62,808	227,078	3.62
1979	49,306	106,629	2.16
1980	8,309	45,768	5.51
1981	11,359	26,268	2.31
1982	63,271		
1983	29,831		
1984	17,172		
1985	5,620		
AVG:	21,500	107,322	5.41 (GM)
MAX:	78,371	461,522	34.56
MIN:	2,490	8,837	1.59

1984 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948	3,889	29,658	7.63
1952	5,963	11,249	1.89
1956	2,490	12,763	5.13
1960	2,902	8,837	3.05
1964	2,745	18,498	6.74
1968	3,838	22,108	5.76
1972	2,802	58,719	20.96
1976	8,306	22,250	2.68
1980	8,309	45,768	5.51
1984	17,172		
AVG:	5,842	25,539	5.18 (GM)
MAX:	17,172	58,719	20.96
MIN:	2,490	8,837	1.89

1985 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1949	10,772	34,705	3.22
1953	5,692	45,268	7.95
1957	10,870	24,583	2.26
1961	3,622	32,923	9.09
1965	6,089	34,890	5.73
1969	7,176	14,875	2.07
1973	2,704	25,180	9.31
1977	5,709	57,980	10.15
1981	11,359	26,268	2.31
1985	5,620		
AVG:	6,961	32,958	4.81 (GM)
MAX:	11,359	57,980	10.15
MIN:	2,704	14,875	2.07

1986 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1950	11,049	162,026	14.66
1954	24,774	461,522	18.63
1958	78,371	195,518	2.49
1962	57,836	176,546	3.05
1966	28,698	141,828	4.94
1970	11,971	226,369	18.91
1974	44,588	181,851	4.08
1978	62,808	227,078	3.62
1982	63,271		
AVG:	42,596	221,592	6.41 (GM)
MAX:	78,371	461,522	18.91
MIN:	11,049	141,828	2.49

1987 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1951	24,320	68,943	2.83
1955	8,971	310,002	34.56
1959	52,310	175,980	3.36
1963	71,654	114,086	1.59
1967	13,361	220,851	16.53
1971	19,028	135,310	7.11
1975	36,828	217,930	5.92
1979	49,306	106,629	2.16
1983	29,831		
AVG:	33,957	168,716	5.46 (GM)
MAX:	71,654	310,002	34.56
MIN:	8,971	68,943	1.59

Appendix A. Table 13.

SCOTCH RIVER SOCKEYE

ALL YEARS

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948	10	51	5.10
1949	1,764	6,519	3.70
1950	44		
1951			
1952	12	35	2.92
1953	1,364	9,499	6.96
1954			
1955			
1956	8	952	119.00
1957	2,230	1,220	0.55
1958		23	
1959			
1960	11		
1961	598	8,185	13.69
1962	7	2,717	388.14
1963			
1964		222	
1965	1,910	16,637	8.71
1966	459	2,956	6.44
1967			
1968			
1969	3,395	34,003	10.02
1970	304	2,236	7.36
1971		39	
1972			
1973	6,235	55,304	8.87
1974	447	9,824	21.98
1975			
1976	34	279	8.21
1977	13,586	78,489	5.78
1978	2,056	41,506	20.19
1979			
1980	107	1,283	11.99
1981	18,952	25,422	1.34
1982	4,709		
1983	239		
1984	409		
1985	3,385		
AVG:	2,491	13,518	9.09 (GM)
MAX:	18,952	78,489	388.14
MIN:	7	23	0.55

1984 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948	10	51	5.10
1952	12	35	2.92
1956	8	952	119.00
1960	11		
1964		222	
1968			
1972			
1976	34	279	8.21
1980	107	1,283	11.99
1984	409		
AVG:	84	470	11.17 (GM)
MAX:	409	1,283	119.00
MIN:	8	35	2.92

1985 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1949	1,764	6,519	3.70
1953	1,364	9,499	6.96
1957	2,230	1,220	0.55
1961	598	8,185	13.69
1965	1,910	16,637	8.71
1969	3,395	34,003	10.02
1973	6,235	55,304	8.87
1977	13,586	78,489	5.78
1981	18,952	25,422	1.34
1985	3,385		
AVG:	5,342	26,142	4.72 (GM)
MAX:	18,952	78,489	13.69
MIN:	598	1,220	0.55

1986 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1950	44		
1954			
1958		23	
1962	7	2,717	388.14
1966	459	2,956	6.44
1970	304	2,236	7.36
1974	447	9,824	21.98
1978	2,056	41,506	20.19
1982	4,709		
AVG:	1,147	9,877	24.12 (GM)
MAX:	4,709	41,506	388.14
MIN:	7	23	6.44

1987 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1951			
1955			
1959			
1963			
1967			
1971		39	
1975			
1979			
1983	239		
AVG:	239	39	(GM)
MAX:	239	39	ERR
MIN:	239	39	ERR

Appendix A. Table 14.

LOWER ADAMS SOCKEYE

ALL YEARS

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948	10,356	22,876	2.21
1949	3,593	34,871	9.71
1950	1,259,381	9,814,596	7.79
1951	143,498	529,379	3.69
1952	7,317	17,932	2.45
1953	3,472	30,998	8.93
1954	2,009,231	15,789,570	7.86
1955	63,836	863,549	13.53
1956	3,321	8,227	2.48
1957	2,807	25,825	9.20
1958	3,287,678	2,132,621	0.65
1959	134,545	378,352	2.81
1960	1,907	2,606	1.37
1961	1,118	6,419	5.74
1962	1,113,088	2,867,521	2.58
1963	156,454	3,112,002	19.89
1964	604	19,478	32.25
1965	1,795	50,849	28.33
1966	1,255,893	3,947,763	3.14
1967	838,945	3,120,311	3.72
1968	3,686	20,773	5.64
1969	4,986	12,652	2.54
1970	1,495,504	5,146,834	3.44
1971	283,791	655,449	2.31
1972	4,153	42,522	10.24
1973	1,014	74,447	73.42
1974	1,061,774	6,394,532	6.02
1975	155,517	994,994	6.40
1976	4,750	13,494	2.84
1977	6,151	56,776	9.23
1978	1,699,329	8,246,094	4.85
1979	288,777	1,473,585	5.10
1980	2,482	34,959	14.08
1981	6,218	3,427	0.55
1982	2,506,038	6,760,897	2.70
1983	204,030		
1984	4,248		
1985	471		
AVG:	474,520	2,077,348	5.20 (GM)
MAX:	3,287,678	15,789,570	73.42
MIN:	471	2,606	0.55

1984 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948	10,356	22,876	2.21
1952	7,317	17,932	2.45
1956	3,321	8,227	2.48
1960	1,907	2,606	1.37
1964	604	19,478	32.25
1968	3,686	20,773	5.64
1972	4,153	42,522	10.24
1976	4,750	13,494	2.84
1980	2,482	34,959	14.08
1984	4,248		
AVG:	4,282	20,319	4.80 (GM)
MAX:	10,356	42,522	32.25
MIN:	604	2,606	1.37

1985 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1949	3,593	34,871	9.71
1953	3,472	30,998	8.93
1957	2,807	25,825	9.20
1961	1,118	6,419	5.74
1965	1,795	50,849	28.33
1969	4,986	12,652	2.54
1973	1,014	74,447	73.42
1977	6,151	56,776	9.23
1981	6,218	3,427	0.55
1985	471		
AVG:	3,163	32,918	7.92 (GM)
MAX:	6,218	74,447	73.42
MIN:	471	3,427	0.55

1986 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1950	1,259,381	9,814,596	7.79
1954	2,009,231	15,789,570	7.86
1958	3,287,678	2,132,621	0.65
1962	1,113,088	2,867,521	2.58
1966	1,255,893	3,947,763	3.14
1970	1,495,504	5,146,834	3.44
1974	1,061,774	6,394,532	6.02
1978	1,699,329	8,246,094	4.85
1982	2,506,038	6,760,897	2.70
AVG:	1,743,102	6,788,936	3.54 (GM)
MAX:	3,287,678	15,789,570	7.86
MIN:	1,061,774	2,132,621	0.65

1987 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1951	143,498	529,379	3.69
1955	63,836	863,549	13.53
1959	134,545	378,352	2.81
1963	156,454	3,112,002	19.89
1967	838,945	3,120,311	3.72
1971	283,791	655,449	2.31
1975	155,517	994,994	6.40
1979	288,777	1,473,585	5.10
1983	204,030		
AVG:	252,155	1,390,953	5.45 (GM)
MAX:	838,945	3,120,311	19.89
MIN:	63,836	378,352	2.31

Includes all late run Shuswap Lake except Lower Shuswap system sockeye

Appendix A. Table 15. LOWER SHUSWAP RIVER SOCKEYE

ALL YEARS

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948			
1949	13	13,994	1076.46
1950	12,000	126,844	10.57
1951		203	
1952			
1953		29	
1954	17,462	79,766	4.57
1955	23	1,971	85.70
1956			
1957	2	1,040	520.00
1958	9,367	57,231	6.11
1959	281	3,950	14.06
1960		22	
1961	32	1,956	61.13
1962	31,027	57,486	1.85
1963	2,014	19,344	9.60
1964		5	
1965	292	4,892	16.75
1966	24,415	73,379	3.01
1967	5,951	63,912	10.74
1968		1,154	
1969	999	21,427	21.45
1970	28,799	429,887	14.93
1971	6,117	46,676	7.63
1972	39	379	9.72
1973	2,794	17,604	6.30
1974	85,950	709,941	8.26
1975	11,622	31,579	2.72
1976	30	648	21.60
1977	6,359	36,869	5.80
1978	187,134	1,786,270	9.55
1979	10,048	30,191	3.00
1980	18	631	35.08
1981	4,075	6,039	1.48
1982	513,897		
1983	7,308		
1984	75		
1985	817		
AVG:	32,299	116,946	12.89 (GM)
MAX:	513,897	1,786,270	1076.46
MIN:	2	5	1.48

1984 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948			
1952			
1956			
1960		22	
1964		5	
1968		1,154	
1972	39	379	9.72
1976	30	648	21.60
1980	18	631	35.08
1984	75		
AVG:	41	473	19.45 (GM)
MAX:	75	1,154	35.08
MIN:	18	5	9.72

1985 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1949	13	13,994	1076.46
1953		29	
1957	2	1,040	520.00
1961	32	1,956	61.13
1965	292	4,892	16.75
1969	999	21,427	21.45
1973	2,794	17,604	6.30
1977	6,359	36,869	5.80
1981	4,075	6,039	1.48
1985	817		
AVG:	1,709	11,539	30.05 (GM)
MAX:	6,359	36,869	1076.46
MIN:	2	29	1.48

1986 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1950	12,000	126,844	10.57
1954	17,462	79,766	4.57
1958	9,367	57,231	6.11
1962	31,027	57,486	1.85
1966	24,415	73,379	3.01
1970	28,799	429,887	14.93
1974	85,950	709,941	8.26
1978	187,134	1,786,270	9.55
1982	513,897		
AVG:	101,117	415,100	6.11 (GM)
MAX:	513,897	1,786,270	14.93
MIN:	9,367	57,231	1.85

1987 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1951		203	
1955	23	1,971	85.70
1959	281	3,950	14.06
1963	2,014	19,344	9.60
1967	5,951	63,912	10.74
1971	6,117	46,676	7.63
1975	11,622	31,579	2.72
1979	10,048	30,191	3.00
1983	7,308		
AVG:	5,421	24,728	9.64 (GM)
MAX:	11,622	63,912	85.70
MIN:	23	203	2.72

Appendix A. Table 16.

SHUSWAP LAKE TOTAL SOCKEYE

ALL YEARS

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948	14,255	52,585	3.69
1949	16,142	90,089	5.58
1950	1,282,474	10,103,466	7.88
1951	167,818	598,525	3.57
1952	13,292	29,216	2.20
1953	10,528	85,794	8.15
1954	2,051,467	16,330,858	7.96
1955	72,830	1,175,522	16.14
1956	5,819	21,942	3.77
1957	15,909	52,668	3.31
1958	3,375,416	2,385,393	0.71
1959	187,136	558,282	2.98
1960	4,820	11,465	2.38
1961	5,370	49,483	9.21
1962	1,201,958	3,104,268	2.58
1963	230,122	3,245,432	14.10
1964	3,349	38,203	11.41
1965	10,086	107,268	10.64
1966	1,309,465	4,165,926	3.18
1967	858,257	3,405,074	3.97
1968	7,524	44,035	5.85
1969	16,556	82,957	5.01
1970	1,536,578	5,805,326	3.78
1971	308,936	837,474	2.71
1972	6,994	101,620	14.53
1973	12,747	172,535	13.54
1974	1,192,759	7,296,148	6.12
1975	203,967	1,244,503	6.10
1976	13,120	36,671	2.80
1977	31,805	230,064	7.23
1978	1,951,327	10,300,948	5.28
1979	348,131	1,610,405	4.63
1980	10,916	82,641	7.57
1981	40,604	61,156	1.51
1982	3,087,915	10,204,780	3.30
1983	241,408		
1984	21,904		
1985	10,293		
AVG:	523,158	2,392,078	4.93 (GM)
MAX:	3,375,416	16,330,858	16.14
MIN:	3,349	11,465	0.71

1984 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948	14,255	52,585	3.69
1952	13,292	29,216	2.20
1956	5,819	21,942	3.77
1960	4,820	11,465	2.38
1964	3,349	38,203	11.41
1968	7,524	44,035	5.85
1972	6,994	101,620	14.53
1976	13,120	36,671	2.80
1980	10,916	82,641	7.57
1984	21,904		
AVG:	10,199	46,486	4.85 (GM)
MAX:	21,904	101,620	14.53
MIN:	3,349	11,465	2.20

1985 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1949	16,142	90,089	5.58
1953	10,528	85,794	8.15
1957	15,909	52,668	3.31
1961	5,370	49,483	9.21
1965	10,086	107,268	10.64
1969	16,556	82,957	5.01
1973	12,747	172,535	13.54
1977	31,805	230,064	7.23
1981	40,604	61,156	1.51
1985	10,293		
AVG:	17,004	103,557	6.05 (GM)
MAX:	40,604	230,064	13.54
MIN:	5,370	49,483	1.51

1986 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1950	1,282,474	10,103,466	7.88
1954	2,051,467	16,330,858	7.96
1958	3,375,416	2,385,393	0.71
1962	1,201,958	3,104,268	2.58
1966	1,309,465	4,165,926	3.18
1970	1,536,578	5,805,326	3.78
1974	1,192,759	7,296,148	6.12
1978	1,951,327	10,300,948	5.28
1982	3,087,915	10,204,780	3.30
AVG:	1,887,707	7,744,124	3.75 (GM)
MAX:	3,375,416	16,330,858	7.96
MIN:	1,192,759	2,385,393	0.71

1987 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1951	167,818	598,525	3.57
1955	72,830	1,175,522	16.14
1959	187,136	558,282	2.98
1963	230,122	3,245,432	14.10
1967	858,257	3,405,074	3.97
1971	308,936	837,474	2.71
1975	203,967	1,244,503	6.10
1979	348,131	1,610,405	4.63
1983	241,408		
AVG:	290,956	1,584,402	5.41 (GM)
MAX:	858,257	3,405,074	16.14
MIN:	72,830	558,282	2.71

Includes Adams, Lower Shuswap, Little River, Shuswap Lake, Scotch, Seymour.

Appendix A. Table 17. RAFT RIVER SOCKEYE

ALL YEARS

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948	10,359	63,337	6.11
1949	6,113	39,626	6.48
1950	6,404	45,556	7.11
1951	8,544	47,653	5.58
1952	15,617	51,182	3.28
1953	7,904	32,124	4.06
1954	9,988	50,488	5.05
1955	5,079	60,522	11.92
1956	9,037	27,140	3.00
1957	6,860	21,015	3.06
1958	10,214	23,143	2.27
1959	10,210	23,614	2.31
1960	5,513	16,948	3.07
1961	7,293	24,325	3.34
1962	7,613	40,549	5.33
1963	8,683	9,817	1.13
1964	5,177	48,724	9.41
1965	6,624	20,626	3.11
1966	6,244	23,539	3.77
1967	1,279	9,658	7.55
1968	8,089	106,397	13.15
1969	5,537	14,370	2.60
1970	4,462	8,860	1.99
1971	801	12,361	15.43
1972	11,048	58,837	5.33
1973	2,714	3,863	1.42
1974	2,383	7,261	3.05
1975	2,609	8,053	3.09
1976	8,665	19,914	2.30
1977	617	6,692	10.85
1978	2,493	16,086	6.45
1979	1,758	2,514	1.43
1980	5,418	52,505	9.69
1981	815	7,443	9.13
1982	2,992		
1983	2,780		
1984	19,086		
1985	3,638		
AVG:	6,333	29,551	4.34 (GM)
MAX:	19,086	106,397	15.43
MIN:	617	2,514	1.13

1984 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948	10,359	63,337	6.11
1952	15,617	51,182	3.28
1956	9,037	27,140	3.00
1960	5,513	16,948	3.07
1964	5,177	48,724	9.41
1968	8,089	106,397	13.15
1972	11,048	58,837	5.33
1976	8,665	19,914	2.30
1980	5,418	52,505	9.69
1984	19,086		
AVG:	9,801	49,443	5.19 (GM)
MAX:	19,086	106,397	13.15
MIN:	5,177	16,948	2.30

1985 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1949	6,113	39,626	6.48
1953	7,904	32,124	4.06
1957	6,860	21,015	3.06
1961	7,293	24,325	3.34
1965	6,624	20,626	3.11
1969	5,537	14,370	2.60
1973	2,714	3,863	1.42
1977	617	6,692	10.85
1981	815	7,443	9.13
1985	3,638		
AVG:	4,812	18,898	4.07 (GM)
MAX:	7,904	39,626	10.85
MIN:	617	3,863	1.42

1986 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1950	6,404	45,556	7.11
1954	9,988	50,488	5.05
1958	10,214	23,143	2.27
1962	7,613	40,549	5.33
1966	6,244	23,539	3.77
1970	4,462	8,860	1.99
1974	2,383	7,261	3.05
1978	2,493	16,086	6.45
1982	2,992		
AVG:	5,866	26,935	3.99 (GM)
MAX:	10,214	50,488	7.11
MIN:	2,383	7,261	1.99

1987 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1951	8,544	47,653	5.58
1955	5,079	60,522	11.92
1959	10,210	23,614	2.31
1963	8,683	9,817	1.13
1967	1,279	9,658	7.55
1971	801	12,361	15.43
1975	2,609	8,053	3.09
1979	1,758	2,514	1.43
1983	2,780		
AVG:	4,638	21,774	4.16 (GM)
MAX:	10,210	60,522	15.43
MIN:	801	2,514	1.13

Appendix A. Table 18. FENNELL CREEK SOCKEYE

ALL YEARS

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948			
1949			
1950			
1951			
1952			
1953			
1954		20	
1955		152	
1956			
1957			
1958	5	27	5.40
1959	27	1,114	41.26
1960		4,120	
1961			
1962		2,145	
1963	436	6,534	14.99
1964	146	3,637	24.91
1965		259	
1966		411	
1967	916	15,201	16.59
1968	954	15,037	15.76
1969	52	881	16.94
1970	9	740	82.22
1971	1,293	16,707	12.92
1972	1,931	28,899	14.97
1973	205	2,805	13.68
1974	140	299	2.14
1975	4,005	72,617	18.13
1976	4,090	23,900	5.84
1977	355	8,855	24.94
1978	107	4,527	42.31
1979	15,565	11,238	0.72
1980	8,437	17,581	2.08
1981	2,076	4,444	2.14
1982	1,132		
1983	4,977		
1984	11,021		
1985	1,598		
AVG:	2,586	9,686	11.00 (GM)
MAX:	15,565	72,617	82.22
MIN:	5	20	0.72

1984 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948			
1952			
1956			
1960		4,120	
1964	146	3,637	24.91
1968	954	15,037	15.76
1972	1,931	28,899	14.97
1976	4,090	23,900	5.84
1980	8,437	17,581	2.08
1984	11,021		
AVG:	4,430	15,529	9.35 (GM)
MAX:	11,021	28,899	24.91
MIN:	146	3,637	2.08

1985 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1949			
1953			
1957			
1961			
1965		259	
1969	52	881	16.94
1973	205	2,805	13.68
1977	355	8,855	24.94
1981	2,076	4,444	2.14
1985	1,598		
AVG:	857	3,449	10.55 (GM)
MAX:	2,076	8,855	24.94
MIN:	52	259	2.14

1986 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1950			
1954		20	
1958	5	27	5.40
1962		2,145	
1966		411	
1970	9	740	82.22
1974	140	299	2.14
1978	107	4,527	42.31
1982	1,132		
AVG:	279	1,167	14.15 (GM)
MAX:	1,132	4,527	82.22
MIN:	5	20	2.14

1987 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1951			
1955		152	
1959	27	1,114	41.26
1963	436	6,534	14.99
1967	916	15,201	16.59
1971	1,293	16,707	12.92
1975	4,005	72,617	18.13
1979	15,565	11,238	0.72
1983	4,977		
AVG:	3,888	17,652	10.96 (GM)
MAX:	15,565	72,617	41.26
MIN:	27	152	0.72

Appendix A. Table 19. WEAVER CREEK SOCKEYE

ALL YEARS

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948	19,431	131,635	6.77
1949	12,725	55,002	4.32
1950	30,539	184,157	6.03
1951	12,856	117,511	9.14
1952	28,050	11,006	0.39
1953	8,789	218,207	24.83
1954	28,137	235,297	8.36
1955	21,636	72,868	3.37
1956	8,690	21,608	2.49
1957	20,237	8,842	0.44
1958	35,939	31,072	0.86
1959	8,363	39,259	4.69
1960	7,033	4,623	0.66
1961	4,246	57,809	13.61
1962	15,924	47,938	3.01
1963	14,469	166,479	11.51
1964	1,196	25,040	20.94
1965	17,924	205,659	11.47
1966	19,489	76,161	3.91
1967	22,581	88,405	3.92
1968	3,799	155,396	40.90
1969	58,727	412,913	7.03
1970	10,435	384,038	36.80
1971	4,990	155,255	31.11
1972	25,738	342,374	13.30
1973	48,541	355,612	7.33
1974	64,093	276,337	4.31
1975	29,736	145,953	4.91
1976	49,932	304,515	6.10
1977	52,627	234,642	4.46
1978	75,171	1,123,838	14.95
1979	45,026	175,741	3.90
1980	73,830	401,627	5.44
1981	42,002	209,727	4.99
1982	294,083	815,200	2.77
1983	39,341		
1984	59,602		
1985	36,545		
AVG:	35,591	208,335	5.63 (GM)
MAX:	294,083	1,123,838	40.90
MIN:	1,196	4,623	0.39

1984 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948	19,431	131,635	6.77
1952	28,050	11,006	0.39
1956	8,690	21,608	2.49
1960	7,033	4,623	0.66
1964	1,196	25,040	20.94
1968	3,799	155,396	40.90
1972	25,738	342,374	13.30
1976	49,932	304,515	6.10
1980	73,830	401,627	5.44
1984	59,602		
AVG:	27,730	155,314	4.90 (GM)
MAX:	73,830	401,627	40.90
MIN:	1,196	4,623	0.39

1985 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1949	12,725	55,002	4.32
1953	8,789	218,207	24.83
1957	20,237	8,842	0.44
1961	4,246	57,809	13.61
1965	17,924	205,659	11.47
1969	58,727	412,913	7.03
1973	48,541	355,612	7.33
1977	52,627	234,642	4.46
1981	42,002	209,727	4.99
1985	36,545		
AVG:	30,236	195,379	5.88 (GM)
MAX:	58,727	412,913	24.83
MIN:	4,246	8,842	0.44

1986 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1950	30,539	184,157	6.03
1954	28,137	235,297	8.36
1958	35,939	31,072	0.86
1962	15,924	47,938	3.01
1966	19,489	76,161	3.91
1970	10,435	384,038	36.80
1974	64,093	276,337	4.31
1978	75,171	1,123,838	14.95
1982	294,083	815,200	2.77
AVG:	63,757	352,671	5.31 (GM)
MAX:	294,083	1,123,838	36.80
MIN:	10,435	31,072	0.86

1987 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1951	12,856	117,511	9.14
1955	21,636	72,868	3.37
1959	8,363	39,259	4.69
1963	14,469	166,479	11.51
1967	22,581	88,405	3.92
1971	4,990	155,255	31.11
1975	29,736	145,953	4.91
1979	45,026	175,741	3.90
1983	39,341		
AVG:	22,111	120,181	6.66 (GM)
MAX:	45,026	175,741	31.11
MIN:	4,990	39,259	3.37

Appendix A. Table 20.

BIRKENHEAD RIVER SOCKEYE

ALL YEARS

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948	83,787	206,696	2.47
1949	70,504	308,662	4.38
1950	64,440	242,740	3.77
1951	21,296	216,719	10.18
1952	47,041	244,678	5.20
1953	42,491	156,143	3.67
1954	18,213	175,704	9.65
1955	14,553	280,383	19.27
1956	49,754	279,109	5.61
1957	14,536	75,666	5.21
1958	15,166	130,934	8.63
1959	26,159	268,572	10.27
1960	36,838	168,936	4.59
1961	31,681	131,851	4.16
1962	26,369	103,783	3.94
1963	48,893	455,775	9.32
1964	48,908	365,993	7.48
1965	16,230	163,901	10.10
1966	20,116	317,710	15.79
1967	39,876	492,216	12.34
1968	57,947	285,925	4.93
1969	37,382	791,710	21.18
1970	30,656	736,305	24.02
1971	24,629	371,401	15.08
1972	54,516	515,310	9.45
1973	56,653	328,391	5.80
1974	119,637	918,986	7.68
1975	61,538	127,367	2.07
1976	77,305	632,531	8.18
1977	23,845	460,202	19.30
1978	94,782	776,704	8.19
1979	60,988	511,892	8.39
1980	78,613	170,015	2.16
1981	49,023	109,423	2.23
1982	119,738	1,231,700	10.29
1983	44,029		
1984	38,644		
1985	11,905		
AVG:	46,807	364,401	7.12 (GM)
MAX:	119,738	1,231,700	24.02
MIN:	11,905	75,666	2.07

1984 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948	83,787	206,696	2.47
1952	47,041	244,678	5.20
1956	49,754	279,109	5.61
1960	36,838	168,936	4.59
1964	48,908	365,993	7.48
1968	57,947	285,925	4.93
1972	54,516	515,310	9.45
1976	77,305	632,531	8.18
1980	78,613	170,015	2.16
1984	38,644		
AVG:	57,335	318,799	5.02 (GM)
MAX:	83,787	632,531	9.45
MIN:	36,838	168,936	2.16

1985 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1949	70,504	308,662	4.38
1953	42,491	156,143	3.67
1957	14,536	75,666	5.21
1961	31,681	131,851	4.16
1965	16,230	163,901	10.10
1969	37,382	791,710	21.18
1973	56,653	328,391	5.80
1977	23,845	460,202	19.30
1981	49,023	109,423	2.23
1985	11,905		
AVG:	35,425	280,661	6.42 (GM)
MAX:	70,504	791,710	21.18
MIN:	11,905	75,666	2.23

1986 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1950	64,440	242,740	3.77
1954	18,213	175,704	9.65
1958	15,166	130,934	8.63
1962	26,369	103,783	3.94
1966	20,116	317,710	15.79
1970	30,656	736,305	24.02
1974	119,637	918,986	7.68
1978	94,782	776,704	8.19
1982	119,738	1,231,700	10.29
AVG:	56,569	514,952	8.76 (GM)
MAX:	119,738	1,231,700	24.02
MIN:	15,166	103,783	3.77

1987 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1951	21,296	216,719	10.18
1955	14,553	280,383	19.27
1959	26,159	268,572	10.27
1963	48,893	455,775	9.32
1967	39,876	492,216	12.34
1971	24,629	371,401	15.08
1975	61,538	127,367	2.07
1979	60,988	511,892	8.39
1983	44,029		
AVG:	37,996	340,541	9.39 (GM)
MAX:	61,538	511,892	19.27
MIN:	14,553	127,367	2.07

Appendix A. Table 21.

HARRISON RIVER SOCKEYE

ALL YEARS

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948	26,162	43,283	1.65
1949	8,000	37,073	4.63
1950	33,044	78,099	2.36
1951	17,145	122,022	7.12
1952	25,794	23,054	0.89
1953	21,080	9,784	0.47
1954	28,800	14,797	0.51
1955	5,595	141,038	25.21
1956	2,586	96,972	37.50
1957	3,793	60,554	15.96
1958	14,701	59,892	4.07
1959	27,868	41,545	1.49
1960	17,210	29,451	1.71
1961	42,773	13,225	0.31
1962	8,162	50,812	6.23
1963	22,258	87,825	3.95
1964	2,202	51,204	23.25
1965	15,034	20,432	1.36
1966	32,646	55,444	1.70
1967	20,548	50,935	2.48
1968	5,379	17,838	3.32
1969	14,959	7,302	0.49
1970	12,666	39,763	3.14
1971	3,790	84,459	22.28
1972	1,346	1,963	1.46
1973	3,060	34,273	11.20
1974	16,920	61,696	3.65
1975	5,987	79,412	13.26
1976	5,130	24,781	4.83
1977	2,246	24,058	10.71
1978	19,717	31,658	1.61
1979	45,615	15,910	0.35
1980	5,092	8,542	1.68
1981	3,193	31,673	9.92
1982	9,189	4,275	0.47
1983	4,239		
1984	1,267		
1985			
AVG:	14,463	44,430	3.05 (GM)
MAX:	45,615	141,038	37.50
MIN:	1,267	1,963	0.31

1984 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948	26,162	43,283	1.65
1952	25,794	23,054	0.89
1956	2,586	96,972	37.50
1960	17,210	29,451	1.71
1964	2,202	51,204	23.25
1968	5,379	17,838	3.32
1972	1,346	1,963	1.46
1976	5,130	24,781	4.83
1980	5,092	8,542	1.68
1984	1,267		
AVG:	9,217	33,010	3.54 (GM)
MAX:	26,162	96,972	37.50
MIN:	1,267	1,963	0.89

1985 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1949	8,000	37,073	4.63
1953	21,080	9,784	0.47
1957	3,793	60,554	15.96
1961	42,773	13,225	0.31
1965	15,034	20,432	1.36
1969	14,959	7,302	0.49
1973	3,060	34,273	11.20
1977	2,246	24,058	10.71
1981	3,193	31,673	9.92
1985			
AVG:	12,676	26,486	2.73 (GM)
MAX:	42,773	60,554	15.96
MIN:	2,246	7,302	0.31

1986 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1950	33,044	78,099	2.36
1954	28,800	14,797	0.51
1958	14,701	59,892	4.07
1962	8,162	50,812	6.23
1966	32,646	55,444	1.70
1970	12,666	39,763	3.14
1974	16,920	61,696	3.65
1978	19,717	31,658	1.61
1982	9,189	4,275	0.47
AVG:	19,538	44,048	1.97 (GM)
MAX:	33,044	78,099	6.23
MIN:	8,162	4,275	0.47

1987 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1951	17,145	122,022	7.12
1955	5,595	141,038	25.21
1959	27,868	41,545	1.49
1963	22,258	87,825	3.95
1967	20,548	50,935	2.48
1971	3,790	84,459	22.28
1975	5,987	79,412	13.26
1979	45,615	15,910	0.35
1983	4,239		
AVG:	17,005	77,893	4.77 (GM)
MAX:	45,615	141,038	25.21
MIN:	3,790	15,910	0.35

Appendix A. Table 22.

PORTAGE CREEK SOCKEYE

ALL YEARS

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948			
1949			
1950			
1951	29	244	8.41
1952			
1953	50	394	7.88
1954	3,369	38,700	11.49
1955	41	4,392	107.12
1956			
1957	40	47	1.18
1958	4,736	25,645	5.41
1959	572	5,565	9.73
1960			
1961	23	2,723	118.39
1962	11,935	72,180	6.05
1963	2,011	58,437	29.06
1964	9	624	69.33
1965	981	3,463	3.53
1966	31,343	31,339	1.00
1967	4,025	4,286	1.06
1968	86	1,046	12.16
1969	963	34,612	35.94
1970	3,873	58,068	14.99
1971	281	18,043	64.21
1972	190	15,283	80.44
1973	3,963	68,692	17.33
1974	8,475	41,580	4.91
1975	3,175	13,549	4.27
1976	1,042	8,042	7.72
1977	7,610	39,710	5.22
1978	9,978	81,592	8.18
1979	3,575	65,073	18.20
1980	1,800	14,340	7.97
1981	5,755	16,077	2.79
1982	23,867		
1983	7,747		
1984	1,701		
1985	1,703		
AVG:	4,530	25,848	10.55 (GM)
MAX:	31,343	81,592	118.39
MIN:	9	47	1.00

1984 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948			
1952			
1956			
1960			
1964	9	624	69.33
1968	86	1,046	12.16
1972	190	15,283	80.44
1976	1,042	8,042	7.72
1980	1,800	14,340	7.97
1984	1,701		
AVG:	805	7,867	21.09 (GM)
MAX:	1,800	15,283	80.44
MIN:	9	624	7.72

1985 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1949			
1953	50	394	7.88
1957	40	47	1.18
1961	23	2,723	118.39
1965	981	3,463	3.53
1969	963	34,612	35.94
1973	3,963	68,692	17.33
1977	7,610	39,710	5.22
1981	5,755	16,077	2.79
1985	1,703		
AVG:	2,343	20,715	8.77 (GM)
MAX:	7,610	68,692	118.39
MIN:	23	47	1.18

1986 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1950			
1954	3,369	38,700	11.49
1958	4,736	25,645	5.41
1962	11,935	72,180	6.05
1966	31,343	31,339	1.00
1970	3,873	58,068	14.99
1974	8,475	41,580	4.91
1978	9,978	81,592	8.18
1982	23,867		
AVG:	12,197	49,872	5.82 (GM)
MAX:	31,343	81,592	14.99
MIN:	3,369	25,645	1.00

1987 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1951	29	244	8.41
1955	41	4,392	107.12
1959	572	5,565	9.73
1963	2,011	58,437	29.06
1967	4,025	4,286	1.06
1971	281	18,043	64.21
1975	3,175	13,549	4.27
1979	3,575	65,073	18.20
1983	7,747		
AVG:	2,384	21,199	13.85 (GM)
MAX:	7,747	65,073	107.12
MIN:	29	244	1.06

Note - Includes Seton Creek and Bridge River.

Appendix A. Table 23.

GATES CREEK SOCKEYE

ALL YEARS

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948		30,026	
1949		590	
1950		300	
1951		623	
1952	7,070	38,000	5.37
1953	74	7,885	106.55
1954	45	698	15.51
1955	77	2,505	32.53
1956	7,807	15,990	2.05
1957	891	1,163	1.31
1958	61	441	7.23
1959	582	10,655	18.31
1960	5,413	84,049	15.53
1961	268	14,706	59.30
1962	159	524	3.30
1963	4,113	7,648	1.86
1964	19,396	105,060	5.42
1965	1,642	3,087	1.88
1966	65	936	14.40
1967	1,138	6,661	5.85
1968	10,113	82,525	8.16
1969	777	5,001	6.44
1970	78	580	7.44
1971	426	12,647	29.69
1972	8,323	132,617	15.93
1973	795	12,525	15.75
1974	70	1,992	28.46
1975	1,982	22,413	11.31
1976	17,133	73,413	4.28
1977	2,582	21,804	8.44
1978	258	1,806	7.00
1979	3,828	17,860	4.67
1980	25,088	81,226	3.24
1981	4,670	14,951	3.20
1982	930		
1983	7,784		
1984	28,801		
1985	4,578		
AVG:	4,912	23,908	8.42 (GM)
MAX:	28,801	132,617	106.55
MIN:	45	300	1.31

1984 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948		30,026	
1952	7,070	38,000	5.37
1956	7,807	15,990	2.05
1960	5,413	84,049	15.53
1964	19,396	105,060	5.42
1968	10,113	82,525	8.16
1972	8,323	132,617	15.93
1976	17,133	73,413	4.28
1980	25,088	81,226	3.24
1984	28,801		
AVG:	14,349	71,434	6.00 (GM)
MAX:	28,801	132,617	15.93
MIN:	5,413	15,990	2.05

1985 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1949		590	
1953	74	7,885	106.55
1957	891	1,163	1.31
1961	268	14,706	59.30
1965	1,642	3,087	1.88
1969	777	5,001	6.44
1973	795	12,525	15.75
1977	2,582	21,804	8.44
1981	4,670	14,951	3.20
1985	4,578		
AVG:	1,806	9,077	8.98 (GM)
MAX:	4,670	21,804	106.55
MIN:	74	590	1.31

1986 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1950		300	
1954	45	698	15.51
1958	61	441	7.23
1962	159	524	3.30
1966	65	936	14.40
1970	78	580	7.44
1974	70	1,992	28.46
1978	258	1,806	7.00
1982	930		
AVG:	208	910	9.67 (GM)
MAX:	930	1,992	28.46
MIN:	45	300	3.30

1987 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1951		623	
1955	77	2,505	32.53
1959	582	10,655	18.31
1963	4,113	7,648	1.86
1967	1,138	6,661	5.85
1971	426	12,647	29.69
1975	1,982	22,413	11.31
1979	3,828	17,860	4.67
1983	7,784		
AVG:	2,491	10,127	10.02 (GM)
MAX:	7,784	22,413	32.53
MIN:	77	623	1.86

Appendix A. Table 26. UPPER PITT RIVER SOCKEYE

ALL YEARS

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948	55,380	122,720	2.22
1949	9,290	20,778	2.24
1950	40,061	146,337	3.65
1951	37,837	120,302	3.18
1952	48,899	72,178	1.48
1953	18,673	25,807	1.38
1954	17,624	51,094	2.90
1955	17,950	166,957	9.30
1956	32,094	70,323	2.19
1957	12,335	29,207	2.37
1958	10,381	16,535	1.59
1959	15,731	62,493	3.97
1960	24,510	33,314	1.36
1961	11,158	103,035	9.23
1962	16,580	57,275	3.45
1963	12,680	142,935	11.27
1964	13,756	192,094	13.96
1965	6,966	38,984	5.60
1966	20,842	77,701	3.73
1967	10,282	67,780	6.59
1968	16,988	105,588	6.22
1969	25,073	61,083	2.44
1970	6,642	55,398	8.34
1971	15,452	217,474	14.07
1972	13,412	138,157	10.30
1973	11,895	43,163	3.63
1974	20,581	118,137	5.74
1975	39,920	65,701	1.65
1976	36,525	105,700	2.89
1977	13,852	26,137	1.89
1978	24,786	30,643	1.24
1979	37,542	29,312	0.78
1980	17,101	17,974	1.05
1981	25,327	2,416	0.10
1982	8,708		
1983	16,852		
1984	15,797		
1985	3,560		
AVG:	20,606	77,492	3.06 (GM)
MAX:	55,380	217,474	14.07
MIN:	3,560	2,416	0.10

1984 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948	55,380	122,720	2.22
1952	48,899	72,178	1.48
1956	32,094	70,323	2.19
1960	24,510	33,314	1.36
1964	13,756	192,094	13.96
1968	16,988	105,588	6.22
1972	13,412	138,157	10.30
1976	36,525	105,700	2.89
1980	17,101	17,974	1.05
1984	15,797		
AVG:	27,446	95,339	3.10 (GM)
MAX:	55,380	192,094	13.96
MIN:	13,412	17,974	1.05

1985 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1949	9,290	20,778	2.24
1953	18,673	25,807	1.38
1957	12,335	29,207	2.37
1961	11,158	103,035	9.23
1965	6,966	38,984	5.60
1969	25,073	61,083	2.44
1973	11,895	43,163	3.63
1977	13,852	26,137	1.89
1981	25,327	2,416	0.10
1985	3,560		
AVG:	13,813	38,957	2.04 (GM)
MAX:	25,327	103,035	9.23
MIN:	3,560	2,416	0.10

1986 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1950	40,061	146,337	3.65
1954	17,624	51,094	2.90
1958	10,381	16,535	1.59
1962	16,580	57,275	3.45
1966	20,842	77,701	3.73
1970	6,642	55,398	8.34
1974	20,581	118,137	5.74
1978	24,786	30,643	1.24
1982	8,708		
AVG:	18,467	69,140	3.26 (GM)
MAX:	40,061	146,337	8.34
MIN:	6,642	16,535	1.24

1987 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1951	37,837	120,302	3.18
1955	17,950	166,957	9.30
1959	15,731	62,493	3.97
1963	12,680	142,935	11.27
1967	10,282	67,780	6.59
1971	15,452	217,474	14.07
1975	39,920	65,701	1.65
1979	37,542	29,312	0.78
1983	16,852		
AVG:	22,694	109,117	4.46 (GM)
MAX:	39,920	217,474	14.07
MIN:	10,282	29,312	0.78

Appendix A. Table 25.

CULTUS LAKE SOCKEYE

ALL YEARS

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948	12,746	76,559	6.01
1949	9,055	97,875	10.81
1950	29,928	278,991	9.32
1951	12,677	207,031	16.33
1952	17,833	67,147	3.77
1953	11,543	114,272	9.90
1954	22,036	127,133	5.77
1955	25,922	397,965	15.35
1956	13,718	37,285	2.72
1957	20,375	28,920	1.42
1958	13,324	71,552	5.37
1959	47,779	82,109	1.72
1960	17,640	41,009	2.32
1961	13,396	13,083	0.98
1962	26,997	60,111	2.23
1963	20,303	322,265	15.87
1964	11,067	75,808	6.85
1965	2,455	32,600	13.28
1966	16,919	133,772	7.91
1967	33,198	150,058	4.52
1968	25,314	54,800	2.16
1969	5,942	7,963	1.34
1970	13,941	44,807	3.21
1971	9,128	49,467	5.42
1972	10,366	31,462	3.04
1973	641	749	1.17
1974	8,984	29,917	3.33
1975	11,349	115,787	10.20
1976	4,435	6,129	1.38
1977	82	1,571	19.16
1978	5,076	49,624	9.78
1979	32,031	97,737	3.05
1980	1,657	11,667	7.04
1981	256	1,336	5.22
1982	16,725		
1983	19,944		
1984	994		
1985	424		
AVG:	14,374	85,840	4.66 (GM)
MAX:	47,779	397,965	19.16
MIN:	82	749	0.98

1984 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1948	12,746	76,559	6.01
1952	17,833	67,147	3.77
1956	13,718	37,285	2.72
1960	17,640	41,009	2.32
1964	11,067	75,808	6.85
1968	25,314	54,800	2.16
1972	10,366	31,462	3.04
1976	4,435	6,129	1.38
1980	1,657	11,667	7.04
1984	994		
AVG:	11,577	44,652	3.41 (GM)
MAX:	25,314	76,559	7.04
MIN:	994	6,129	1.38

1985 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1949	9,055	97,875	10.81
1953	11,543	114,272	9.90
1957	20,375	28,920	1.42
1961	13,396	13,083	0.98
1965	2,455	32,600	13.28
1969	5,942	7,963	1.34
1973	641	749	1.17
1977	82	1,571	19.16
1981	256	1,336	5.22
1985	424		
AVG:	6,417	33,152	4.07 (GM)
MAX:	20,375	114,272	19.16
MIN:	82	749	0.98

1986 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1950	29,928	278,991	9.32
1954	22,036	127,133	5.77
1958	13,324	71,552	5.37
1962	26,997	60,111	2.23
1966	16,919	133,772	7.91
1970	13,941	44,807	3.21
1974	8,984	29,917	3.33
1978	5,076	49,624	9.78
1982	16,725		
AVG:	17,103	99,488	5.20 (GM)
MAX:	29,928	278,991	9.78
MIN:	5,076	29,917	2.23

1987 CYCLE YEAR

Brood Year	Adult Escapement	Total Return	Return Per Spawner
1951	12,677	207,031	16.33
1955	25,922	397,965	15.35
1959	47,779	82,109	1.72
1963	20,303	322,265	15.87
1967	33,198	150,058	4.52
1971	9,128	49,467	5.42
1975	11,349	115,787	10.20
1979	32,031	97,737	3.05
1983	19,944		
AVG:	23,592	177,802	6.91 (GM)
MAX:	47,779	397,965	16.33
MIN:	9,128	49,467	1.72

Appendix B. Table 1. Estimates of bias in Ricker a and b parameters in Monte Carlo simulations (n=100). Results are based on runs with 33 stock and recruit data pairs. Exploitation rates were applied to maintain the stock at the optimal escapements for each a-b combination.

Percent Deviation from true a

Ricker a/b	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50
0.05	6.86	2.18	4.31	0.56	0.20	2.93	2.29	0.45	0.63	0.36	-0.18
0.10	6.90	6.15	1.77	1.15	4.63	-0.22	1.31	2.06	0.50	0.09	1.07
0.15	7.84	2.38	4.84	2.96	2.19	0.17	2.56	1.13	-0.93	2.05	1.15
0.20	6.79	3.78	5.73	0.69	1.87	2.84	1.74	-0.34	1.58	1.28	0.51
0.25	8.67	7.10	2.32	0.57	3.03	-0.08	2.23	2.34	1.64	-0.22	0.51
0.30	9.69	3.38	2.69	4.39	1.42	-0.16	2.72	0.12	0.44	1.92	2.86
0.35	13.21	5.07	5.19	-0.88	2.15	1.09	1.92	2.07	1.11	0.40	0.03
0.40	4.57	4.96	5.08	4.81	1.09	2.53	0.02	1.75	0.99	1.70	0.61
0.45	5.94	0.68	3.76	4.59	1.24	3.29	-0.17	-0.40	0.31	0.90	0.63
0.50	7.56	1.33	2.13	3.47	1.52	4.19	2.46	0.92	-0.73	0.24	0.73
0.55	6.85	9.55	2.33	1.57	-0.10	1.92	1.59	3.20	1.40	-0.64	0.30
0.60	3.76	5.70	3.87	4.42	3.86	0.32	-0.39	1.40	0.32	2.01	1.39
0.65	6.20	2.79	3.87	1.44	0.87	4.97	1.24	0.28	1.80	0.42	0.45
0.70	6.76	3.43	2.12	5.25	1.96	1.75	-0.33	2.78	2.77	0.81	1.73
0.75	3.34	4.47	1.77	7.20	2.03	2.61	1.08	-1.02	-0.54	2.02	3.04
0.80	7.53	4.53	5.48	2.35	1.82	0.35	3.01	2.02	0.71	0.95	-0.64
0.85	6.92	3.89	4.06	2.27	2.86	1.09	1.33	0.06	2.07	0.44	0.81
0.90	4.32	3.90	3.01	3.43	2.63	1.55	1.54	0.47	0.99	0.66	0.60
0.95	7.10	4.33	1.71	3.28	0.33	1.75	1.71	0.49	0.73	1.79	-0.25
1.00	9.15	8.05	2.55	3.00	0.19	2.53	1.05	0.94	2.45	1.29	-0.20

Percent deviation from true b

Ricker a/b	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50
0.05	18.51	10.79	12.04	4.93	5.90	8.72	5.15	2.67	3.62	2.45	1.99
0.10	17.24	14.49	4.41	4.85	10.93	0.76	5.47	5.05	1.97	-0.54	5.23
0.15	17.68	11.11	11.62	9.72	7.11	0.62	7.58	4.70	-0.97	6.41	5.04
0.20	18.06	11.73	10.34	5.64	5.58	6.26	5.15	3.17	4.73	4.73	2.43
0.25	20.64	15.28	10.85	4.85	7.73	2.23	7.37	6.00	5.63	1.51	2.37
0.30	20.70	10.13	6.29	9.35	4.54	3.45	5.14	0.91	3.11	6.47	7.55
0.35	21.77	17.48	16.64	0.36	6.20	2.83	3.77	6.99	6.46	2.75	2.28
0.40	13.39	11.51	12.61	10.62	4.68	6.03	2.85	4.78	3.58	5.39	3.49
0.45	14.56	5.00	7.85	12.14	2.55	8.37	2.80	-0.15	2.50	1.18	1.81
0.50	13.05	6.86	5.05	8.51	7.13	9.54	5.66	3.32	-1.39	0.78	4.70
0.55	17.45	19.26	5.87	5.14	0.41	5.89	10.72	7.86	3.40	0.07	1.49
0.60	5.33	21.96	12.83	9.93	7.77	2.62	-2.61	5.62	2.21	6.40	3.34
0.65	18.30	9.31	6.74	5.23	6.25	9.56	4.10	4.49	4.05	0.84	3.73
0.70	16.12	6.28	7.43	13.99	3.17	5.10	2.17	5.32	7.12	4.91	5.48
0.75	-0.09	12.28	5.51	13.66	6.91	13.21	1.22	-2.38	-0.73	4.75	8.31
0.80	12.94	12.51	14.75	6.90	5.35	2.32	8.21	4.81	4.08	5.24	-2.14
0.85	13.25	9.93	7.74	6.22	10.77	4.09	3.83	2.28	5.45	0.23	2.69
0.90	11.62	11.20	6.87	7.17	4.90	4.50	4.50	2.18	4.06	2.75	2.26
0.95	20.34	10.54	4.00	7.77	3.62	4.70	2.66	0.84	1.85	5.27	0.61
1.00	23.44	15.42	6.57	7.68	1.25	6.21	7.24	3.82	5.70	4.17	0.17

Appendix B Table 2. Estimates of bias in Ricker a and b parameters in Monte Carlo simulations (n=100). Results are based on runs with 10 stock and recruit data pairs. Exploitation rates were applied to maintain the stock at the optimal escapements for each a-b combination.

Percent deviation from true a

Ricker a/b	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50
0.05	16.91	16.19	18.52	17.05	10.36	11.32	2.70	2.56	0.62	0.29	4.35
0.10	33.23	25.60	19.95	17.28	2.38	2.71	2.71	-0.21	6.77	6.61	5.75
0.15	33.53	23.96	6.51	4.88	3.89	0.99	7.77	6.54	7.40	7.02	6.93
0.20	25.09	13.12	11.43	8.83	8.55	12.32	8.93	10.67	5.37	0.33	1.82
0.25	24.55	13.73	13.34	12.63	12.38	8.68	10.30	5.12	3.80	0.69	1.02
0.30	28.04	26.91	20.49	19.03	13.52	4.20	1.38	0.32	-1.74	2.49	5.60
0.35	28.43	26.59	18.57	7.37	5.07	4.78	2.36	6.09	9.97	9.38	6.36
0.40	26.89	11.96	9.49	9.12	7.72	6.55	9.65	6.85	6.00	4.53	2.98
0.45	18.26	18.53	10.15	13.88	12.77	11.18	9.38	6.89	3.08	2.34	1.22
0.50	32.96	16.80	14.55	14.78	6.94	8.53	6.61	3.63	2.74	1.47	2.55
0.55	19.87	18.31	13.67	14.62	15.56	11.46	9.82	8.34	6.77	3.52	2.03
0.60	29.04	21.62	11.39	7.50	6.35	3.87	1.93	1.13	0.46	-0.31	1.41
0.65	27.42	25.60	20.99	15.35	13.85	8.75	7.90	8.03	3.96	3.34	-0.34
0.70	8.35	7.75	4.49	5.25	4.54	3.54	1.86	5.54	7.89	8.80	7.99
0.75	37.85	16.08	19.20	9.67	7.75	4.63	3.34	2.21	1.12	0.69	1.20
0.80	16.04	12.16	9.51	15.07	13.95	12.48	11.04	7.24	4.32	3.68	2.69
0.85	18.80	12.11	5.55	5.05	3.76	-0.34	1.63	2.20	3.28	4.78	5.44
0.90	31.21	23.20	12.91	13.76	9.51	4.45	5.73	3.39	0.02	-0.49	-0.90
0.95	6.89	7.26	10.37	9.59	7.95	6.98	8.56	7.55	4.87	4.85	3.30
1.00	22.92	11.16	8.21	1.76	0.65	0.52	0.12	4.42	3.57	4.52	3.21

Percent deviation from true b

Ricker a/b	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50
0.05	128.59	69.41	83.84	64.88	40.73	38.08	23.29	16.89	10.19	9.84	22.71
0.10	85.56	76.24	53.53	57.88	24.23	22.84	19.18	10.57	29.70	26.13	22.29
0.15	103.95	94.91	50.81	30.10	21.25	17.62	25.63	24.46	25.65	23.25	25.05
0.20	78.25	44.45	51.18	51.47	29.50	41.28	31.27	27.60	21.83	6.23	8.45
0.25	111.97	65.60	41.76	34.14	29.37	20.88	26.67	23.59	20.67	14.52	16.83
0.30	80.93	70.83	54.91	44.60	31.82	22.47	14.98	11.83	9.30	10.75	18.78
0.35	46.56	47.55	36.41	30.28	32.61	34.19	13.90	22.20	30.12	25.72	19.34
0.40	48.14	73.01	52.49	46.12	32.61	23.24	20.29	19.35	18.13	11.62	21.88
0.45	80.87	63.34	45.71	45.47	30.63	29.10	21.45	19.41	13.56	15.75	14.31
0.50	98.18	48.88	29.46	33.10	12.40	21.81	20.97	20.32	18.40	11.24	11.55
0.55	38.49	39.84	30.79	35.14	23.42	26.56	25.45	22.64	21.42	29.62	15.93
0.60	82.85	57.00	22.01	15.01	5.68	5.19	8.24	17.33	12.36	5.55	11.30
0.65	53.29	52.49	44.35	41.11	39.34	34.88	32.70	29.37	22.31	9.71	-4.19
0.70	5.51	9.09	8.92	30.25	21.36	25.47	11.82	16.71	20.14	25.57	26.80
0.75	78.59	60.28	56.77	33.06	24.66	10.40	2.52	0.87	2.37	0.47	10.04
0.80	63.03	60.96	37.98	38.59	35.06	34.91	27.28	26.15	24.07	17.57	17.10
0.85	38.83	16.04	6.67	5.81	4.30	3.19	12.07	12.35	16.06	15.90	18.60
0.90	70.37	57.46	36.70	44.39	30.59	17.94	19.10	12.47	-1.63	-1.67	-3.26
0.95	10.37	17.81	34.35	36.73	26.74	24.03	26.27	24.08	18.19	15.09	16.31
1.00	47.41	29.30	17.95	5.85	-0.54	2.12	1.99	12.13	12.84	14.98	21.08

Appendix B Table 3. Estimates of bias in Ricker a and b parameters in Monte Carlo simulations (n=100). Results are based on runs with 33 stock and recruit data pairs. Exploitation rates were applied to overexploit the stock at 10% below the optimal escapements for each a-b combination.

Percent deviation from true a

Ricker a/b	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50
0.05	11.53	8.83	3.88	0.76	1.37	3.70	4.87	3.90	0.77	-0.15	0.82
0.10	12.18	7.68	3.24	1.99	2.17	4.29	4.53	3.69	0.64	0.39	0.86
0.15	14.67	6.15	2.77	1.01	3.56	4.86	3.90	4.32	1.17	0.07	0.60
0.20	8.95	2.20	1.43	2.74	3.47	5.40	3.53	4.62	1.21	-0.75	0.94
0.25	8.71	2.05	2.70	4.53	4.58	3.26	3.73	6.03	1.12	-0.67	0.60
0.30	6.00	3.94	3.82	3.65	4.16	2.74	3.50	5.23	0.09	-0.81	0.94
0.35	6.77	4.01	5.74	3.53	0.90	3.14	3.03	5.03	-0.20	-0.43	0.44
0.40	11.07	7.72	3.18	4.98	3.37	2.75	2.16	2.28	1.33	0.49	0.86
0.45	7.48	5.73	4.94	4.21	3.56	1.89	1.90	4.19	1.08	0.15	0.32
0.50	10.21	5.62	5.37	2.39	0.82	1.96	2.14	4.65	1.03	-0.26	0.42
0.55	10.92	5.98	3.30	3.18	2.77	2.42	2.05	4.76	0.75	0.31	0.23
0.60	7.36	6.25	0.48	3.92	3.27	2.48	3.90	4.05	0.15	0.43	0.43
0.65	3.53	5.71	1.41	2.24	1.79	3.22	4.14	3.57	0.22	0.47	0.39
0.70	5.77	2.65	1.85	2.34	4.22	4.10	4.17	2.76	0.18	0.63	0.47
0.75	6.70	5.82	2.23	3.33	3.06	4.42	3.98	2.21	0.53	0.23	0.39
0.80	4.47	6.11	4.01	4.12	3.90	4.29	3.88	2.99	0.76	0.45	0.03
0.85	7.35	5.74	4.49	3.81	3.74	4.52	3.26	4.09	0.70	-0.04	0.26
0.90	5.67	4.11	3.17	5.18	2.19	5.00	3.09	4.18	0.52	0.23	0.37
0.95	5.00	8.07	4.31	4.01	3.56	4.18	3.37	3.38	0.62	-0.24	0.28
1.00	11.16	5.14	3.30	4.42	4.08	3.21	3.82	3.11	0.51	-0.34	0.08

Percent deviation from true b

Ricker a/b	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50
0.05	40.21	25.36	13.95	5.57	15.24	22.15	64.34	299.04	1014.80	6307.23	2132.03
0.10	34.08	25.83	11.83	10.08	15.96	28.87	39.02	249.94	847.59	-1164.41	880.36
0.15	35.30	18.89	13.10	6.40	15.67	27.65	56.29	285.20	937.05	-4721.15	618.70
0.20	21.51	12.33	13.40	16.88	15.69	27.42	48.15	345.10	996.10	-6063.18	348.40
0.25	27.97	13.17	15.98	18.11	18.85	15.39	54.90	420.73	670.70	-4130.04	272.50
0.30	23.24	19.97	20.69	9.82	12.82	21.93	72.48	364.97	253.90	-4056.09	264.50
0.35	35.21	23.26	19.14	9.98	5.72	26.92	46.04	408.43	-62.46	-4633.93	331.69
0.40	25.33	21.61	16.38	21.66	18.75	15.19	17.62	127.36	559.47	2111.61	86.29
0.45	18.92	16.85	23.38	21.39	18.95	12.39	18.36	250.85	458.81	654.89	288.71
0.50	29.09	22.74	25.31	16.85	6.38	10.52	27.28	216.48	306.78	-717.67	211.75
0.55	30.58	21.87	14.88	14.99	9.89	17.71	32.74	186.27	146.87	-895.53	87.95
0.60	23.80	20.92	4.26	15.30	14.56	19.90	36.67	143.84	33.03	-179.27	-42.53
0.65	17.08	18.15	6.91	14.13	13.69	23.73	46.19	118.10	48.28	651.45	-214.30
0.70	17.38	8.93	6.41	12.75	20.59	26.25	43.84	82.37	125.29	1340.68	-240.85
0.75	15.77	14.79	9.69	16.80	17.81	27.69	38.18	71.05	271.53	1484.93	-141.72
0.80	9.76	14.70	15.01	18.54	19.48	24.17	30.71	125.13	290.91	1536.21	-8.04
0.85	15.05	13.80	17.13	20.71	22.13	22.97	28.00	170.57	307.02	1055.14	83.99
0.90	14.24	13.24	14.44	24.51	9.42	24.83	24.91	180.14	257.49	210.05	89.15
0.95	15.89	24.73	19.00	20.12	11.71	16.54	39.66	140.28	204.27	-624.47	117.69
1.00	25.10	19.83	16.63	15.90	17.34	19.55	44.54	114.93	137.51	-969.35	106.33

Appendix B Table 4. Estimates of bias in Ricker a and b parameters in Monte Carlo simulations (n=100). Results are based on runs with 10 stock and recruit data pairs. Exploitation rates were applied to overexploit the stock at 10% below the optimal escapements for each a-b combination.

Percent deviation from true a

Ricker a/b	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50
0.05	16.85	4.53	4.09	18.60	24.77	25.60	22.57	16.18	6.33	1.00	-0.44
0.10	20.23	31.20	32.15	25.64	22.06	14.00	12.84	12.36	6.60	1.65	2.90
0.15	49.48	34.32	30.16	10.58	6.17	9.14	12.19	12.23	1.89	-2.46	2.69
0.20	31.93	16.34	17.01	10.82	8.79	14.14	15.15	12.01	4.09	-1.72	0.94
0.25	28.49	20.33	15.51	16.19	14.32	14.41	10.91	8.03	4.28	0.33	-0.08
0.30	16.12	28.63	26.71	21.60	22.49	23.30	16.57	10.67	3.29	-0.01	-0.82
0.35	31.53	20.68	15.43	13.76	10.04	7.09	6.83	9.32	4.92	0.98	0.31
0.40	22.74	26.36	24.73	22.11	18.66	15.70	10.65	8.17	2.04	-0.10	1.78
0.45	18.22	13.36	12.02	13.17	10.31	10.05	10.00	9.00	5.18	-0.02	1.70
0.50	39.06	21.50	15.64	10.06	8.55	8.86	5.74	4.14	0.15	-1.18	-0.69
0.55	19.80	17.74	16.93	21.11	16.67	16.18	13.06	9.99	1.91	0.16	-0.37
0.60	16.81	12.66	6.41	3.33	5.15	8.48	12.08	14.71	3.99	-0.11	1.43
0.65	30.17	22.56	20.11	12.58	11.96	8.62	6.34	2.38	-1.15	-0.68	0.41
0.70	19.96	21.42	14.88	14.49	13.92	11.86	11.93	12.52	3.67	1.10	-0.79
0.75	13.62	4.52	3.50	4.66	6.56	8.27	7.42	7.87	2.18	0.15	0.85
0.80	31.05	25.21	16.05	15.38	11.83	6.46	3.95	0.28	0.76	-0.67	-0.11
0.85	18.76	15.61	11.28	13.69	12.86	12.85	15.03	12.56	2.84	0.31	0.60
0.90	24.34	10.51	10.94	10.69	8.08	7.85	4.34	3.68	1.80	0.05	0.93
0.95	40.41	31.71	23.02	11.58	10.60	11.07	11.89	6.43	0.49	-0.84	-0.01
1.00	9.28	7.04	11.22	12.91	13.52	14.01	13.04	10.77	0.46	-0.21	-0.12

Percent deviation from b

Ricker a/b	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50
0.05	323.73	169.25	134.71	190.69	215.74	244.78	320.79	996.31	5773.00	22605.61	-4573.42
0.10	350.40	98.04	89.44	81.08	97.39	134.89	370.88	877.09	1960.05	7768.19	851.44
0.15	117.24	97.72	92.55	95.72	151.69	227.49	395.05	552.95	-34.31	-5020.71	331.42
0.20	62.79	123.53	133.65	118.35	162.42	117.55	105.14	122.91	70.99	-4905.48	-1411.74
0.25	195.91	147.44	138.25	61.95	47.39	54.98	47.40	163.65	939.59	4704.19	-1194.46
0.30	180.24	69.11	54.73	61.22	83.88	108.13	115.51	161.76	59.69	-2806.61	-439.54
0.35	134.55	99.68	80.46	44.49	30.21	28.64	33.69	188.68	821.28	3228.35	-550.14
0.40	116.37	72.40	72.21	91.67	87.67	101.66	151.16	159.39	184.74	355.52	104.81
0.45	25.73	24.74	26.54	72.43	116.09	154.58	164.57	284.46	105.82	-2336.63	286.78
0.50	123.92	90.94	67.65	55.78	44.78	36.06	26.65	22.14	-19.15	128.80	-407.30
0.55	108.11	97.56	100.51	74.06	74.08	105.58	133.84	225.01	146.59	446.10	-35.79
0.60	42.25	21.79	14.37	9.88	17.15	82.98	181.68	372.67	359.64	-241.65	231.44
0.65	89.13	76.70	83.07	58.53	52.95	44.62	46.70	29.65	-24.35	-178.08	18.62
0.70	39.73	93.19	66.17	69.60	75.83	90.65	94.12	270.97	286.09	728.46	-24.80
0.75	34.36	15.89	11.16	10.47	21.86	36.10	53.20	133.25	235.63	-46.58	112.21
0.80	103.48	86.05	67.12	73.56	84.63	46.65	30.66	15.58	0.63	-312.16	13.11
0.85	35.69	41.14	47.26	64.68	75.02	91.50	136.57	186.26	254.15	742.77	-159.84
0.90	117.30	26.71	25.57	26.15	21.29	32.94	40.46	69.23	118.17	464.96	119.49
0.95	109.16	95.81	61.37	59.28	74.51	98.90	164.50	177.16	-0.31	-355.58	69.31
1.00	11.82	29.52	45.24	51.14	65.73	89.62	99.14	141.67	-53.95	-1006.57	-168.13